STATE OF DELAWARE

DEPARTMENT OF TRANSPORTATION

Request for Proposal

Contract ID: DOT1915-FIXED_DMS

APPENDIX A

TECHNICAL SPECIFICATIONS

SPECIFICATIONS

1.0 Reliability and Operational Stability

The vendor shall furnish all necessary equipment inclusive of all parts and components necessary to be a completely operational Dynamic Message Sign (DMS) System unless stated otherwise in these specifications. Compliance with the Specifications pertaining to individual elements of the DMS System does not in itself constitute compliance with the reliability and long-term operational stability of the complete DMS System.

1.1 Materials

The Bidder shall include in the bid price, all cables and incidental items necessary for the complete operation of each DMS System.

All hardware furnished by the vendor shall be new and of recent manufacture; no used or refurbished hardware is allowed. Firmware and software must be tested and in working order; prototype firmware or software will not be permitted.

The vendor shall register with the manufacturer(s) all equipment, firmware, and software in the name of the Department. Electronic Copies of the registration forms shall be forwarded to the Department.

The vendor shall store and handle all materials and equipment in a clean, dry location, free of construction dust, precipitation, and excess moisture in such a manner as not to degrade quality, serviceability, or appearance. This storage environment shall be adhered to but not limited to delivery holding areas and assembly areas.

1.2 Materials and Fabrication

All equipment and component parts furnished shall be new, be of the latest design, recent manufacture, and in operable condition at the time of delivery. No part or attachment shall be substituted or applied contrary to the manufacturer's recommendations and standard practices. All equipment is to be procured from a manufacturer or manufacturers who have been engaged in the manufacture of such equipment for a period of five (5) years or more. Submit certifications from the various manufacturers that ensure essential equipment provided will be carried in factory stock for a period of at least ten (10) years.

All materials for the DMS System shall be new, corrosion-resistant, and unaffected by water spray salt, oil, gasoline, and all other contaminants in the quantities normally found along the edge of the roadway. The DMS System construction, materials, and operations shall conform to all National Electric Code (NEC) and National Fire Protection Association (NFPA) standards.

All electronic equipment shall be of a solid-state design and modular construction. Individual electronic modules shall provide easy service access and shall be field replaceable. The design shall be such as to prevent incorrect assembly or installation of connectors, fasteners, etc., where possible malfunction or personnel hazards might occur. Each item of equipment shall be designed to protect personnel from exposure to high voltage during equipment operation, adjustments, and maintenance.

The DMS System and all associated control and electronics equipment, and enclosures shall be designed for outdoor installation. All environmental testing shall be successfully performed prior to the delivery of the DMS System and/or associated equipment. If requested by the Department, the vendor shall supply manufacturer and/or third-party certification for equipment. Provide all equipment to operate in a range of -22 Degrees F to +165 Degrees F at a relative humidity not exceeding 99%, non-condensing, unless otherwise specified.

All electrical materials and equipment used for which there are established Underwriters Laboratories (UL) and Electrical Testing Laboratories (ETL) standards shall bear the UL and ETL labels.

1.3 Regulations and Codes

All electrical equipment shall conform to the standards of National Electrical Manufacturers Association (NEMA), National Electric Safety Council (NESC), National Fire Protection Agency (NFPA), Federal Communications Commission (FCC), and the Electronic Industries Association/Telecommunications Industry Association (EIA/TIA) where applicable.

All system wiring, conduit, grounding hardware, and circuit breakers shall be in conformance with the issue of the National Electrical Code (NEC) in effect on the date of the bid. All electrical conductors shall be copper.

Otherwise, whenever references are made in these provisions, they are considered to mean the code, ordinance or standard that is in effect at the time of the bid advertisement.

1.4 Quality Assurance

The vendor shall develop a Quality Control Program and submit it to the Department for review and approval within twenty (20) working days after the issuance of the Notice to Proceed. The vendor shall be required to resubmit a Quality Control Program that has been rejected by the Department within seven (7) days for approval unless otherwise noted. The vendor shall follow the approved quality control program for the duration of the Contract. The vendor shall not deliver any equipment prior to the approval of the Quality Control Program. At a minimum, the Quality Control Program must include:

a) The Project Manager and Technical Lead, along with any other key staff, as well as their responsibilities.
b) A description of the manufacturing facility and process used to ensure delivery of equipment consistent with this Contract and Specifications.
c) Standard Delivery time following receipt of a Purchase Order from the Department.

1.5 Modifications to Submitted Equipment

The vendor shall provide updated design documentation for any DMS System Component that has changed from what was originally submitted in response to this RFP for Department review and approval prior to delivery. The vendor shall provide an advanced warning, in writing, if modifications to a particular DMS System component will require a change in spare parts inventory.

1.6 User Manuals and System Administrator Documents

The vendor shall provide operator user manuals sufficient to describe how the system can be deployed, operated, and maintained.

The vendor shall provide manuals for the system administrator sufficient to describe how the system can be administered, including setup, installation, configuration, testing, and maintenance.

Separate Manuals and Administrator Documentation shall be provided for each of the DMS Systems as specified

2.0 Warranty

The vendor shall extend to the Department a policy guarantee on equipment and/or services against defective material and workmanship for a period of at least one (1) year from the date of delivery. Vendors are encouraged to provide extended warranty plans with their bid.

Any item that is normally covered by the warranty policy but is determined to have been damaged through misuse or neglect shall be exempt from coverage. If any part of the unit is normally covered by a warranty policy for more than one year, the full period of warranty policy of that component shall be provided to the Department. The vendor shall be solely responsible for the warranty of equipment by others but provided by the Contractor as part of this Contract including parts and labor for removal and replacement of failed components.

The vendor shall comply with the manufacturer's warranty or authorize a qualified dealer in the locality in which the DMS System is delivered to do whatever is required to comply with the manufacturer's warranty without cost to the Department. When warranty work is required, the Department shall notify the vendor and/or its designated maintenance facility/provider. Upon notification that warranty work is required, the vendor shall be required to respond either by telephone, email, or in-person within five (5) business days after notification by the Department. If the Department and the vendor determine that an on-site visit is necessary, the vendor shall provide the necessary labor force (technicians) necessary within five (5) working days after notification by the Department to perform the necessary repairs. If the provision of replacement parts is required to perform the repair work, affecting the five (5) day response time, the vendor is to immediately notify the Department and provide a corresponding timetable. The vendor shall bear the cost of transporting materials and equipment to/from the work site as well as all labor required to make the repair. All replacement parts shall be newly manufactured and provide a direct replacement for the existing component to be replaced.

During the warranty period, the vendor is responsible for providing the software and/or firmware upgrades to the provided equipment.

Within the warranty period, the Department reserves the right to require the replacement of portions of the whole DMS System at no additional cost under the following circumstances:

a) If one particular component fails more than three (3) times on the same devices within a period of six (6) months.
b) If two or more different components fail more than a combined number of four (4) times on the same device within a period of six (6) months.

The Department shall have the right to request an extension of the warranty period beyond the initial offering for one or more DMS device(s) the additional warranty can be negotiated and agreed upon between both the Department and the vendor.

3.0 Spare Parts

The Bidder shall submit with their bid, a list and price of recommended spare parts for all DMS Systems including all associated equipment, software, and other components that provide for a fully functional DMS System. All spare parts shall be identical to the installed components and to enable the Department or its agent to readily replace defective components. The Department may review the suggested minimum stocked spare parts and cost estimates, and modify/negotiate the terms with the Bidder on those items.

Spare parts required shall be calculated on an estimated number of DMS as follows:

- Five (5) purchased complete Type 1 DMS,
- Five (5) purchased complete Type 2 DMS.
- Five (5) purchased complete Type 3 DMS.
- Five (5) purchased complete Type 4 DMS.
- Four (4) purchased complete Type 5 DMS.
- Four (4) purchased complete Type 6 DMS.
- Thirty (30) purchased complete Type 7 DMS.
- Ten (10) purchased complete Type 8 DMS.

The Department will be responsible for the provision of all spare parts related to the communication on DMS devices and central TMC software.

All spare parts provided shall be newly manufactured and identical to originally supplied equipment. If original replacement parts are no longer available, all spare parts shall be a direct replacement for the originally installed equipment.

The spare parts shall be provided as a complete assembly with all items necessary for replacement. The spare part replacement should not require any uncommon tools; however, if uncommon tools are necessary, they must be provided along with the spare part components.

The vendor shall be required to provide spare parts to the Department within fifteen (15) working days after receipt of an approved purchase order throughout the duration of the Contract, including any contract extensions.

For the duration of the Contract, if the vendor or Manufacturer discontinues or improves upon any spare part or equipment, the vendor shall submit an updated spare parts list to the Department, including the price for each item. Pricing for any replacement spare parts or equipment shall be similar to that originally submitted.

4.0 Integration

All permanent DMS systems are to be controlled through the Department's Advanced Traffic Management Software (ATMS), Q-Free OpenTMS, located in the Department Transportation Management Center in Smyrna, DE. The proposer shall coordinate with the Department and the Department's software vendor (Q-Free) to aid in the connection and integration of provided DMS.

The proposer will also make available their DMS control software to the Department for use in the event that issues arise with the ATMS.

5.0 Testing

This work entails providing testing services and documents for all DMS System equipment provided under this contract.

Provide testing services to verify that all equipment and systems meet or exceed the Technical Requirements defined in future sections of this document. As part of the response to the RFP, provide copies of all testing procedures and documentation. These documents will be utilized to conduct DMS testing throughout the duration of this contract. Copies of the completed test procedures must be provided for each device provided under this contract.

The vendor is to conduct the following tests for each device/device type provided under this contract:

1. Factory Acceptance Test
2. On-Site Test
3. Operational Acceptance Test

Reports and records of each test and each inspection must be submitted for approval. The original results are to contain the original forms filled out by the persons performing the inspection/tests, and the original signatures. Forms are to be filled out in ink. Errors are to be crossed out with a single line and initialed by the person making the correction. Include a cover letter signed by the project manager with each set of inspection/test results.

Include the following in each set of test results:

1. The completed set of procedures used.
2. The completed, signed set of forms used including serial/lot numbers of individual equipment.
3. A summary of the test performed.

Each submitted test procedure is to include, at a minimum:

1. Unique Title
2. The purpose of the test to be conducted, including reference to the corresponding test plan requirements, and functions covered by the procedures.
3. Specified design and performance requirements.
4. Cases and conditions covered by the test procedures.
5. Testing/measuring equipment and/or tools to be utilized.
6. Testing configuration/setup instructions
7. Step-by-step instructions for performing the procedure including where data is to be recorded.
8. Expected test results including minimum and maximum thresholds if required.

Test forms are to be provided as integral components to the testing procedure for all equipment except in the case of individual components that do not warrant the need for a comprehensive testing procedure. For all other forms, the following is required:

1. Test title, requirements to be tested, and procedures
2. Test date and the name/signature of the person conducting the test.
3. Manufacturer and model number of all test equipment.

4. Calibration data and standard for each piece of testing equipment (if required), certified by a recognized testing facility.

Upon receipt of completed test forms and procedures, the Department will compare the test results with the requirements specified herein. Failure to conform to the requirements of any test will be considered defective and equipment will be subject to rejection by the Department. In the event that the defect is determined, the vendor shall analyze and categorize all defects as to whether they are limited to the specific unit being tested or could potentially cause problems in all such units. Tests that are rejected for not meeting requirements, but limited to a specific unit may be offered again for retest by the vendor providing all non-conforming items have been corrected.

The Department reserves the right to witness, in person, any test being conducted by the vendor.

The acceptance of each stage of testing does not absolve the vendor of their responsibilities under Section 2.0 Warranty. If sufficient issues are encountered during a test phase, the department may require the vendor to return to a previous testing phase for any component or the complete system. If, through testing/re-testing of devices identifies a common failure pattern, the vendor will be required to replace similar equipment or systems within all provided devices.

5.1 Factory Acceptance Testing

It is anticipated that the majority of equipment being provided under this contract will be standard, off-the-shelf having certification of compliance with industry-accepted standards that also meet the technical requirements for each device type. Conduct FAT in accordance with the documentation provided in response to this RFP for each device type proposed upon in the presence of Department Personnel at the vendor's facility. The Department will cover travel cost associated with factory testing if the testing is required. It should be noted that in-person FAT will only be required once for each device type to be supplied. Upon successful FAT for the first of each device type, completed FAT checklists will be accepted in lieu of viewing FAT in person.

On-Site Testing

On-Site Tests will verify that all equipment has been installed properly in the field and is fully operational in a local mode (at the field site). Following installation and commissioning of the provided equipment, support DelDOT personnel and/or project construction contractors to conduct On-Site Tests in accordance with the provided procedures to verify the acceptance of all installed equipment. The submitted on-site test procedures shall verify that all installed equipment meets or exceeds performance specifications contained herein when installed in the field.

5.2 Operational Acceptance Test

A 60-day Operational Acceptance Test will commence following the complete integration of the provided device into DelDOT's ATMS software. The intent of the Operational Acceptance Test is to ensure that there are no system defects that will inhibit the operation of supplied equipment/systems on an ongoing basis. During this time, DMS systems will be fully operated by TMC staff. During this time, the vendor will be responsible to support the Department and/or construction contractor for the timely correction of any errors or issues that are encountered. If a

fault is found to be related to the supplied equipment, it is the responsibility of the vendor to provide a repair or replacement component(s). Ninety (90) total days will be provided to ensure 60 clean days. If and individual DMS system in non-functional for greater than 30 days within the overall 90 days provided, it will be considered defective and the OAT will be restarted.

6.0 Coordination of Work

The vendor will be provided with a purchase order, from the Department that may or may not be in conjunction with a capital transportation improvement project. In the event that a purchase order is part of a capital construction project, the vendor will have to coordinate with the project contractor for a suitable delivery site for the supplied equipment. Otherwise, it is intended that delivery will be made to a Department facility. In all cases, the vendor must provide notice of delivery within three weeks of the anticipated delivery date to ensure that accommodations can be made to receive and store the provided equipment. All deliveries are to be made within 90 days from the purchase order provided by the Department.

The vendor will not be responsible for the physical installation of the provided equipment in the field, unless stated otherwise in the proposal. The proposer will, however, be responsible to provide on-site assistance up to two (2) trips under each purchase order to assist in the installation, commissioning and/or testing of the devices. Additional visits that may be required due to vendor equipment that is non-functional will be the responsibility of the vendor.

All power, communications, foundation, structure and attachment details for each DMS will be designed and furnished by others.

7.0 Training

The vendor shall submit a system training plan to the Department within thirty (30) days of Notice to Proceed. Once the training plan is approved, the vendor shall use it to provide formal system training for up to fifteen (15) Department staff, on-site at the Department's chosen location. The Department will be responsible for scheduling training activities and identifying staff to be trained This work is to provide the Department's personnel and/or representatives with operations, maintenance, replacement techniques, and support training program including courseware, material, and services for the entire DMS System. The vendor shall provide copies of all training materials for each person being trained.

The Department may review and respond in writing on all submitted training plans within fifteen (15) days from submission. The vendor shall be required to resubmit training plans rejected by the Department within fifteen (15) days from the return of the original submittal unless otherwise noted. The vendor shall clearly note any changes, deviations, or other modifications on the resubmittal.

The vendor shall provide training on the proper installation, assembly, testing, disassembly, uninstallation, transportation, handling, operation, maintenance, support, replacement, and safety of the operations for the complete DMS System.

The training requirements defined herein shall consist of, but not be limited to, furnishing all labor, materials, and transportation for the planning, organizing, and executing of training. The vendor shall provide an instructor at the location of the Department's choice to conduct training courses.

The vendor shall be responsible for updating all training materials if the DMS System has been upgraded or modified in any way during the duration of the Contract.

7.1 Maintenance Training Requirements

The purpose of this training is to provide Department employees as well as others a training course in the operation, circuit description, preventative maintenance procedures, troubleshooting, field adjustments, and/or calibration and repair/replacement of DMS equipment. At a minimum, Maintenance Training shall include the following:

1. Review of basic system configuration and operation
2. Review of preventative maintenance procedures
3. Review of system and software troubleshooting procedures
4. Replacement of component parts
5. Theory of operation
6. Calibration, alignment, and adjustment procedures for equipment
7. Device and cabinet wiring
8. Complete schematics and sub-component part listing

7.2 Operations Training Requirements

The purpose of this training is to provide Department employees as well as others with a training course in the day-to-day operation of the DMS System and its capabilities. At a minimum, Operation Training shall include the following:

1. Equipment handling/transporting
2. System installation
3. System assembly and disassembly
4. System testing
5. Dynamic Message Sign equipment
6. Controller
7. DMS power supply
8. DMS firmware
9. Vendor software
10. Safety procedures
11. Basic operational procedures
12. System, firmware, and vendor software troubleshooting

8.0 Technical Assistance

The vendor shall provide manufacturer-authorized service center staff to provide technical assistance and telephone support as-needed during normal business hours. The vendor shall provide phone numbers that can be contacted for this purpose.

In the event technical assistance is needed, the vendor shall make available a vendor-certified technical resource within 48 hours from the Department placing a call. Technical assistance shall include the installation, assembly, testing, disassembly, un-installation, operation, maintenance, and replacement of DMS Systems. Technical assistance must be provided during the entire duration of the Contract, including any extensions. Technical resources shall be knowledgeable in the following at a minimum:

a) All provided DMS equipment
b) DMS System Controller(s)
c) Electrical and Communications equipment and software
d) DMS System Housings and environmental controls
e) DMS System Power Supply

9.0 NTCIP Conformance

All DMS and associated control equipment shall comply with the latest versions of the National Transportation Communication for ITS Protocol (NTCIP) Standards, as follows:

1. NTCIP 1101:1996 (v01.12, December 2001) – Simple Transportation Management Framework.
2. NTCIP 1103 v03 (December 2016) – Transportation Management Protocols (TMP).
3. NTCIP 1201 (v03, March 2011) – Global Objects (GO) Definitions.
4. NTCIP 1203 (v03, September 2014) –Object Definitions for Dynamic Message Signs (DMS).
5. NTCIP 2101:2001 (v01.19, November 26, 2001) – Point to Multi-Point Protocol Using RS-232 Subnetwork Profile.
6. NTCIP 2103 (v02, December 2008) – Point-to-Point Protocol over RS-232 Subnetwork Profile.
7. NTCIP 2104:2003 (v01.11, September 2005) – Ethernet Subnetwork Profile.
8. NTCIP 2201:2003 (v01.15, September 2005) – Transportation Transport Profile.
9. NTCIP 2202:2001 (v01.05, December 2001) – Internet (TCP/IP and UDP/IP) Transport Profile.
10. NTCIP 2301 (v02.19s, October 2010) – Simple Transportation Management Framework (STMF) Application Profile (AP) (AP-STMF).

Furnish all mandatory objects specified by the NTCIP specifications and all other objects, both NTCIP optional and the manufacturer-specific, that are required to provide the functionality to meet the requirements of these specifications.

Each DMS Component shall support the Full, Standardized Object Range (FSOR) of all objects required by these procurement specifications, unless otherwise indicated or approved by the Department or its Representative.

The DMS system shall not require the support of any agency-specific or manufacturer-specific objects. However, the Proposer shall propose any object definitions necessary to fulfill the above functional requirements that are not addressable by standardized NTCIP-defined object definitions. All functional requirements and the corresponding NTCIP objects have been carefully reviewed and only functions that have corresponding NTCIP objects have been selected. Manufacturer-specific objects may be implemented in the sign controller but they shall in no way required to be used in order to communicate with the sign.

The DMS shall support all mandatory objects of all mandatory Conformance Groups as defined in NTCIP 1201 and NTCIP 1203 and their amendments.

The NTCIP Component shall also implement all mandatory objects of the following optional conformance groups:

1. Time Management, as defined in NTCIP 1201.
2. Timebase Event Schedule, as defined in NTCIP 1201.
3. In the event of a conflict between the Specifications and Standards, the Department or its Representative shall be solely responsible for the identification of the acceptable solution.

10.0 DMS System Type 1 – Full Size, Walk-In, Color

10.1 General

Design and furnish a Light Emitting Diode (LED) Dynamic Message Sign providing a full matrix color display for freeway traveler information applications. The DMS matrix shall be sized sufficient to provide display of three (3) rows of twenty-one (21) characters, with a nominal character size of 18-inches and a pixel pitch of between 0.79 to 0.81 inches. The sign shall provide walk-in access to all interior components.

Provide a fully debugged DMS system complete with all individual units, components, software modules, cabling, connectors, etc. that are completely compatible with each other and are capable of being controlled by the current ATMS being operated at the Department TMC.

10.2 Housing/Enclosure

Design and furnish a DMS enclosure of a design and shape as to house all necessary display modules, display driver electronics, transformers, power supplies, and other internal sign equipment.

Provide a weatherproof housing and internal equipment rated to withstand a humidity range of 0-99% non-condensing.

Construct enclosure of a corrosion-resistant aluminum material conforming to the following:

1. Sheet aluminum shall be fabricated from aluminum alloy sheet meeting the requirements of ASTM B 209, Alloy 5052, Temper H3, or equivalent, minimum 0.125 inch thick. Cast aluminum shall be fabricated from aluminum alloy meeting the requirements of ASTM B 686, Alloy A 356 (A 13560) or equivalent. Flat cast surfaces exceeding 12 inches in both directions shall have a minimum thickness of 0.25 inches. Flat cast surfaces not exceeding 12 inches in both directions shall have a minimum thickness of 0.187 inches.
2. All DMS enclosures shall meet the requirements for TYPE 3R enclosures according to NEMA Standard Publication 250. All seams and openings shall be designed to prevent entry of water resulting from high-pressure washing of the DMS enclosure.
3. Unpainted aluminum DMS enclosures shall be fabricated from mill-finish material and shall be cleaned using appropriate methods that will remove oil, film, weld black, and mill ink marks and render the surface clean, bright, smooth, and non-sticky to touch.
4. Isolate all adjacent dissimilar materials, as approved by the Department.
5. All nuts and bolts used in the DMS assembly shall be stainless steel. All connecting surfaces shall be weatherproof and watertight when secured. All internal components shall be mounted so that there are no external protrusions.
6. The DMS shall be in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except as modified herein: The DMS enclosures shall be designed and constructed to present a clean, neat appearance and the equipment located inside shall be adequately protected from moisture, dust, dirt, corrosion, and excessive heat.

7. All surfaces shall be suitably protected from the weather. All corners and seams shall be heli-arc welded to provide a weatherproof seal around the entire case.
8. The DMS enclosure shall not be adversely affected by salt from the roadways or marine environments or chemicals or fumes discharged from nearby automobiles, industries, and other sources. The interior of the DMS face window and the LEDs shall be easily accessible for cleaning and other maintenance.
9. Appropriate precautions, such as heating elements or ventilation fans or openings, shall be taken to ensure that condensation does not occur between the matrix elements and the DMS window face, and that the environment inside all enclosures remains within the temperature and humidity limits required for proper operation of the sign's electronic components.
10. Provide temperature sensor(s) in the DMS enclosure that is/are controlled and monitored by the DMS controller. Provide the capability for user-defined critical thresholds to be established and changed remotely from the Department TMC or other location using the sign controller.
11. Provide humidity sensor(s) within the DMS enclosure that can detect relative humidity from 0%-100% in 1% or smaller increments. Provide an interface between the humidity sensor and the DMS controller which allows humidity levels to be monitored remotely from the TMC. Provide a sensor with an accuracy that exceeds 5% relative humidity.
12. All hinges used shall be continuous stainless steel, equipped with stainless steel hinge pins. Each hinge shall be secured with stainless steel bolts and locknuts. The hinge pins and bolts shall be tamper-proof.
13. The dead load shall consist of the total weight as installed of the DMS enclosure and appurtenances. The point of application of weights of the individual items shall be their representative centers of gravity.
14. Ice load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except that ice load shall be applied to all sides and top surfaces of the DMS enclosure simultaneously.
15. Wind load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except as modified herein: the enclosure and their mountings shall withstand a sustained wind speed of 90 miles per hour (mph), with a gust factor of 1.3.
16. Full 100 percent impact shall be used for handling and erection stress.

The DMS shall be capable of being mounted without gaining access to the inside of the enclosure. All mounting eyes shall be attached to the DMS enclosure structural framing.

Removal of any of the display modules or any other electronic or electrical component, shall not alter the structural integrity of the DMS display assembly or the DMS enclosure.

Opening door(s) shall allow maintenance personnel immediate access to circuit boards and internal sign parts, without having to remove any item in the sign, or the need to use any tools or to remove any device that could be dropped or lost, such as a locking pin or bolt. Each door shall be sealed to prevent the elements from entering, and shall have at least two locking points to keep unauthorized persons from accessing the interior of the DMS. In addition, each door shall be provided with rigid,

telescopic, retention device, to keep the door in the open position. All doors, when in the open position, shall not obstruct any portion of the opening. The door system shall pull the door tight and compress a gasket located around the perimeter. The gasket shall prevent water from entering the interior of the cabinet.

All serviceable components shall be modular, interchangeable and removable from within the DMS enclosure. The sign design shall allow unobstructed and convenient access to all serviceable components within the DMS enclosure and between the DMS display and the DMS display cover.

Drain holes shall be provided and designed to remove any condensation that may form inside the DMS enclosure and allow any water that may have collected in the housing to escape. All holes shall be screened to prevent small objects, insects, and creatures from entering into the enclosure.

Heating, cooling and/or dehumidifying equipment shall be sized to maintain the internal DMS enclosure temperature within the operating ranges of the electric, electronic and mechanical equipment components. The environmental equipment shall have controls which shall shut down the DMS just prior to the temperature that the interior of the enclosure reaches the rated maximum operating temperature of the LEDs, and shall restore operation when the temperature has returned to safe operating levels. The shutdown shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

Electric ventilation fans shall be provided to generate positive pressure ventilation and shall be sized to provide 25 percent excess ventilation capacity, with one fan inoperative, over that required to maintain the DMS enclosure interior temperature within the range over which the DMS components can operate without failure or degradation, during full daylight heat gain conditions. All fans shall have a ball or roller bearings. Fan operation and failure shall be reported to the DMS Central Processor via the communications protocol.

Louvered air inlets with removable, non-proprietary 500 micron, 2-stage filters, and air deflector, sized to provide a maximum air intake velocity of 600 feet per minute with all fans operating. The direction of airflow and the filter characteristics (i.e., filter model number, type, dimensions, and particle size) shall be permanently engraved on each air vent. Exhaust air vents, if without filters, shall be screened to prevent small objects and creatures from entering into the enclosure.

10.3 LEDs

The LEDs that make up the display modules shall be high luminous intensity T-1 3/4" type manufactured by a reputable manufacturer. The LEDs shall have an ultraviolet light inhibitor in the epoxy dome package and be of a production type already tested for use in high vibration commercial traffic environments and climate of the northeastern United States.

Each Full-color DMS LED module shall be comprised of Red Green and Blue LEDs that meet the following specifications:

1. Red LEDs shall utilize AlInGaP semiconductor technology and shall emit red light that has a peak wavelength of 615-635nm.

2. Green LEDs shall utilize InGaN semiconductor technology and shall emit green light that has a peak wavelength of 520-535nm.
3. Blue LEDs shall utilize InGaN semiconductor technology and shall emit blue light that has a peak wavelength of 464-475nm.

All LEDs shall have a nominal viewing cone of 30 degrees with a half-power angle of 15 degrees measured from the longitudinal axis of the LED.

The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

The LEDs used in the display shall be obtained from batches sorted for luminous output, where the highest luminosity LED in the batch shall not be more than fifty percent more luminous than the lowest luminosity LED in the batch when operated at the manufacturer's recommended drive current. To ensure uniformity of display and operational life, all LEDs used to make up a display module shall be obtained from the same manufacturing batch.

The LED manufacturer shall perform intensity sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive luminous intensity "bins" as defined by the LED manufacturer.

The LED manufacturer shall perform color sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive color "bins" as defined by the LED manufacturer.

The LED mean time before failure (MTBF) shall be a minimum of 100,000 hours of elapsed time calendar hours use in an ambient temperature of 131 degrees Fahrenheit, based on an average daily on-time usage factor of 50%, when driven at the specific forward current recommended by the LED manufacturer for normal daylight DMS display operation. As part of the LED manufacturer's technical specification sheet submittal, the specific forward current shall be noted.

The statistical average long term light output degradation of the LEDs used in the display, operated at the LED manufacturer's recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure in an ambient temperature of 131 degrees Fahrenheit, shall not exceed the following:

1. A maximum of 10% reduction in light output after 10,000 hours of continuous on time.
2. A maximum of 25% reduction in light output after 50,000 hours of continuous on time.
3. A maximum of 30% reduction in light output after 100,000 hours of continuous on-time.
4. Manufacturer's documentation for high temperature operating life (HTOL) shall indicate if HTOL values are based upon actual or extrapolated data.

10.4 Display Modules

The LED display modules shall have a minimum refresh rate of 60 times per second to prevent visible flicker.

The LEDs shall be grouped in pixels consisting of discrete LEDs arranged in a continuous matrix display with individual pixel addressability. The centers of all pixels shall be arranged so as to maintain

the same horizontal and vertical spacing between adjacent pixels. All pixels shall be replaceable. The LED grouping and mounting angle shall be optimized for maximum readability.

The electronics for the DMS shall be fully configured to drive the total required number of LEDs. The failure of any one pixel shall not affect the operation of any other pixel. The power driver circuitry shall be designed to minimize power consumption. Each LED display module shall have a diagnostic capability to detect a failure on the LED display module, down to the pixel level and report the failure to the DMS controller.

Removal of any display module shall not affect the operation of the remaining modules.

The LED modules shall be protected from degradation due to sunlight. The method used shall not obstruct the view of the display or reduce the viewing angle below that provided by an unprotected LED module. The method and design of the DMS sunlight protection shall be approved by the Department.

Each pixel shall contain an adequate number of discrete LEDs, based on a nominal pixel spacing of 0.79 to 0.81 inches, center to center, to meet the luminosity requirements herein.

Each discrete LED on the display module is driven at the LED manufacturer's recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure.

All DMS must be capable of meeting or exceeding the Manual of Uniform Traffic Control Devices (MUTCD) guidelines for inter-character and inter-line spacing of 25% and 50% of character height, respectively.

The 18" character of the Freeway DMS shall be clearly visible and legible from an in-vehicle distance of 1,000 feet from the DMS face under clear daylight and nighttime conditions with the DMS face positioned in the roadway line of sight.

10.5 Dimming Circuitry

The DMS shall have a photocell controlled dimming circuit which shall automatically adjust the luminance of the LED display pixels in accordance with ambient light conditions. As part of the Proposer's submittal, a complete schematic of the LED display power, driver and dimming circuits shall be provided for approval by the Department.

Continuous current drive shall be used at the maximum brightness level. The current used for maximum brightness shall not exceed the current used to achieve the rated mean time before failure (MTBF). The current used for maximum brightness shall be indicated as part of the submittal.

For luminance levels less than maximum brightness, either continuous current drive or current pulse width modulation shall be used to dim the LEDs. If pulse width modulation is used, the dimming circuit shall be designed so that the maximum, instantaneous and average currents shall not exceed the rated peak and transient forward current ratings of the LEDs.

The DMS shall be equipped with a minimum of two external light sensors oriented in opposite directions and shall be scaled for up to 100,000 lux.

The LED dimming circuit shall also incorporate temperature-controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the LED current does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs the DMS shall blank-out, until the temperature has returned to safe operating levels.

The LED dimming circuit shall not cause the LED display to flicker as the temperature oscillates above and below the rated operating temperature of the LEDs.

10.6 Power Supply

The DMS shall be operated at a low internal DC voltage not exceeding 24 Volts.

The quantity of power supplies and current rating of each power supply shall be at least 25% spare capacity over that required to light every pixel of the DMS at full brightness.

The DMS and controller shall have redundant power supplies wired so that in the event of a failure of any one power supply, the second power supply shall automatically power that portion of the sign. Power supply failure shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

The power supplies shall be short circuit protected and shall reset automatically after 5 seconds of AC power off. The power supplies shall be protected by a suitable overcurrent protection device.

The power supply shall have an efficiency rating of 85%, minimum.

The operating temperature range of the power supply inside the DMS enclosure shall be negative 20 degrees Fahrenheit to 140 degrees Fahrenheit.

The power supply shall be UL listed.

10.7 Controller

The DMS controller shall be a microprocessor-based unit with sufficient on-board memory and input and output interfaces to provide all the functions required by this Section.

The DMS controller shall accommodate both local and remote control from multiple host devices as described herein. Local control shall be supported from a locally connected sign programmer. Remote control shall be supported from a remotely located DMS Central Processor (control computer system).

The DMS controller shall receive and interpret commands sent by the host device to either configure the DMS or cause a requested message to be displayed on the DMS. Based on the command, the DMS Controller shall provide return data to the host device to provide information about the status of the sign.

The DMS controller shall be capable of simultaneously receiving commands from and transmitting status data to multiple host devices; i.e., the sign programmer, local control panel and the DMS Central Processor.

The method of control of the DMS shall be dependent upon the setting of the Control Mode Selector switch in each local control panel. This switch shall allow for two modes of operation:

"Remote" mode: This is the normal mode of operation of the DMS, where all control is from a remote DMS Central Processor, via NTCIP data exchanged directly between the remote DMS Central Processor and the DMS controller.

"Local" mode: When the Control Mode Selector switch is in this position, control from the remote DMS Central Processor shall be disabled and the DMS shall be controlled in accordance with commands entered via the message selector switch on the Local Control Panel or an NTCIP data exchanged directly with a locally connected Sign Programmer. When in "local" mode, the remote DMS Central Processor shall still be able to monitor the status of the DMS.

When switching from one mode to another, the DMS shall continue to display its current message, until it receives a command to display another message, from either the remote DMS Central Processor or the local controls, as applicable.

A change of position of the mode selector switch shall be immediately reported to the DMS Central Processor in the form of an alarm, and shall be logged internally at the site CPU for retrieval on the next polling cycle, and in accordance with the communications protocol.

Each DMS controller shall have error detection and reporting features which shall be utilized to guard against incomplete or incorrect information transmission, message generation and display on the DMS, as well as provide the capability to detect a failure down to a replaceable component and report the failure and failed component. All errors and hardware failures shall be logged and reported to the DMS Central Processor or Sign Programmer (if connected) via the communications protocol. The DMS controller shall have the capability to automatically recover from failure conditions when the failure conditions are corrected or the failures are no longer present, and report the restored operation of the DMS to the DMS Central Processor or Sign Programmer (if connected).

The DMS controller shall have diagnostic capabilities features to:

1. Perform redundant checking of all data received and transmitted, and incorporate cyclic redundancy check (CRC) error detection logic, as specified by the NTCIP standards.
2. Validate the content of all received transmissions.
3. Check and report logic or data errors.
4. Monitor status for communication line malfunction or break.
5. Respond to system polling from the DMS Central Processor.
6. Check and report errors in display driver operation.
7. Check and report the failure and location of bad pixels.
8. Check and report the failure of bad fans.
9. Check and report whether the controller cabinet or DMS enclosure door is open or closed.
10. Check the operation and report the failure and location of bad power supplies.
11. Check the duration of power failures.
12. Check and report the number of occurrences the watchdog timer resets the controller.

Whenever any of the following error or failure conditions are detected, the DMS controller shall blank the DMS and shall include the error or failure in the return message:

1. The number of pixels that are not working for the particular sign type exceed a specified maximum value. The Proposer shall determine this number for each sign type and have these numbers approved by the Department.
2. The ratio of the number of pixels that achieve a commanded state divided by the number of pixels commanded to that state exceeds a legibility threshold value. The test shall include only those pixels that are contained in the character positions of the message text.
3. Communication loss greater than a configurable time value measured in minutes. The default value shall be 10 minutes. If a system poll is not received within a configurable threshold period, the controller shall blank all signs connected to it. The configuration of system polling shall also have an option for disabling this feature.
4. Upon detection of a power failure to the DMS controller or the DMS display(s) connected to the controller, the current message displayed on the DMS just prior to the power failure shall be retained in memory.
5. Upon power restoration, the DMS shall remain blank if the duration of the power failure exceeded the configurable long term power failure duration threshold, else the previous message shall be restored to its respective DMS. The default value of the long term power failure duration threshold shall be 10 minutes.
6. Overheating condition in DMS enclosure: The LED dimming circuit shall also incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the it does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs, the DMS shall blank-out until the temperature has returned to safe operating levels.
7. Information on each of the specific failures shall be sent to the DMS Central Processor.

Each DMS controller shall have the capability of displaying messages transmitted directly from a DMS Central Processor or Sign Programmer in addition to displaying locally commanded messages from a pre-programmed local message library. Each sign's local message library shall have the capacity to store a minimum of 256 display messages with related display attributes for each message, such as flashing rate and percent "on" time. The local message library shall consist of:

1. A "changeable, non-volatile" local message library stored in battery-backed RAM. The changeable local message library shall be programmable through both the DMS Central Processor and the Sign Programmer.
2. A "permanent, non-volatile" local message library, stored on EPROM shall be provided. Battery-backed RAM memory shall not be acceptable. If a microprocessor-based controller is used, then EEPROM, flash RAM or similar technology memory devices, programmed as described herein, may be used to store the message library.

Each DMS controller shall write messages on the DMS at a minimum rate of 300 characters per second.

Each DMS controller shall have an easily accessible and clearly labeled ON/OFF switch. When in the "OFF" position all power shall be disconnected from the DMS control electronics and matrix units and the DMS shall blank-out.

The Proposer shall provide a means of establishing a monetary reset switch on the DMS controller. The contact switch shall reset the DMS controller when depressed. Operation of the momentary contact switch shall not require the user to hold the switch in the depressed position for more than 0.25 seconds.

The DMS controller shall interface and communicate with one or more Operator Interfaces, as indicated on the Contract Drawings. Operator Interfaces and associated functions shall be as described elsewhere herein.

The DMS controller shall be provided with all software and hardware required to perform the following functions:

1. Password protection to restrict access to control and configuration functions.
2. Fully programmable parameters for all functions described in this section.
3. Real-time clock and calendar for timing and scheduling of automatic functions. The calendar shall automatically adjust itself for leap years, and for changeover from Standard to Daylight savings time and back.
4. Variable message flash rate and percent "on" time.
    a. Flash rate shall be adjustable in one-tenth second increments.
    b. Percent "on" time shall be adjustable from 0 to 9.9 seconds, in one-tenth second increments.
5. Multi-page messages with variable page display times that are adjustable in one-tenth second increments from 0 to 15.0 seconds.
6. Negative text inversion (or inverse/reverse video) - switch between illuminated text on a dark background or dark text on an illuminated background. Inverse/reverse video shall be implemented with the use of standard NTCIP foreground and background objects.
7. Configurable line justification (center, left or right) with center justification as the default setting.
8. Configurable page justification (top, center, bottom) with center justification as the default setting.
9. Configurable message duration parameter, to specify how long the current message should remain displayed regardless of the status of the communications with the DMS Central Processor.
10. Communications Loss message threshold, to specify how long the current message should remain displayed in the absence of communications with the DMS Central Processor.
11. Control of pixel luminance levels, both directly and based on ambient light levels obtained from the photocells. Luminance levels shall be stored in the DMS controller and shall be adjustable, in a range of 0 to 255, on either a continuous logarithmic basis, to match the normal human eye luminous response characteristic, or a 1/2 incremental dimming basis, where each lower dimming level is 1/2 the previous level.
12. Monitoring of each pixel of the DMS.

13. Monitoring of power failures: When a power failure is detected, the displayed message shall be retained in memory. If power to the DMS controller is restored within a configurable period of time, the last displayed message shall be restored. If the duration of the power failure exceeds the configured period of time, the DMS shall remain blank, until a command to display a message is received. Upon restoration of power, the DMS controller shall report the occurrence, time and duration of the power failure, to the DMS Central Processor or Sign Programmer, if connected.
14. Hardware watchdog timer: The DMS controller shall have a hardware watchdog timer that shall check for a stall condition in the controller hardware, software or firmware. While the DMS controller is powered on, the software shall poll the watchdog timer. Upon reset, the watchdog timer shall initialize its timing circuit. If the watchdog timing circuit times out without being reset by the software, the watchdog counter shall be incremented and the watchdog shall reset the controller to clear a potential stall condition from the hardware, software or firmware and send an error message to the DMS Central Processor or Sign Programmer (if connected) to advise of the condition. The number of occurrences that the watchdog timer resets the controller shall be transmitted to the DMS Central Processor or Sign Programmer (if connected) upon request and then cleared.
15. Programmable Font Sets: The DMS controller shall support multiple programmable font sets. At a minimum, this should include fonts for 6", 9", 12", and 18" character heights, variable and fixed width fonts, and single, double, and triple stroke fonts. Each font set shall be capable of being programmed from the DMS Central Processor or the Sign Programmer if connected. Three of the font sets shall look like the E-modified font set defined by the MUTCD, replicating the appearance of the font used on some static signage on the DMS. A single, double and triple stroke E-modified font shall be provided. Additional font sets may be provided at no additional cost and will be considered as additional value added to the proposal.
16. Each font set shall include, but not be limited to, all upper case letters, numerals, punctuation marks and arrows that are displayed in each of the eight cardinal directions.
17. Customizable and Standard Graphics Library: Provide a suite of pre-generated MUTCD style symbols, along with the ability to modify or create independent symbols, saving of new graphics and color editing. The library should hold a minimum of 50 graphics.
18. The DMS controller shall keep a log of all system errors, malfunctions, automatic operations and locally controlled commands and activities. All logs shall be time and date stamped. The DMS controller shall have sufficient memory to store a minimum of 500 log entries. If 100% of the log storage memory has been reached without a successful download to the DMS Central Processor or a Sign Programmer, the oldest log entry shall be overwritten. The DMS controller shall download all log entries to a DMS Central Processor or Sign Programmer, upon user request from one of these devices and clear the log.
19. The DMS and Controller shall be capable of displaying a minimum of 256 different colors. DMS Controller shall be capable of displaying colors that conform to MUTCD requirements.

10.8 Controller Cabinet

All DMS controller cabinets will be furnished and installed by DelDOT's Traffic Signal/ITS Construction Contractor. Coordinate with DelDOT to confirm size, layout, power supply, and mounting/orientation of DMS controller cabinets prior to executing each individual purchase order.

10.9 Communications

Provide layout space for a cellular modem and antenna, Ethernet network switches, and/or 4.9GHz communications network equipment.

The DMS controller shall have a minimum of two (2) serial data and one (1) Ethernet communications ports to facilitate simultaneous communications for local and remote control, programming, and diagnostics.

When connected to a serial port, the DMS shall automatically use the NTCIP communications stack associated with serial communications, i.e., NTCIP 2101, NTCIP 2201, and NTCIP 2301.

When connected to the Ethernet port, the DMS shall automatically use the NTCIP communications stack associated with Ethernet communications, i.e., NTCIP 2104, NTCIP 2202, and NTCIP 2301. All ports shall be configurable such that:

1. Communications with the serial ports shall support all typical serial baud rates ranging from 1200 to 115,200 baud.
2. Communications with the Ethernet port shall be capable of communicating via TCP/IP or UDP/IP at 10 or 100 MB.

The serial ports in the DMS sign controller shall be protected with surge protection to protect the modem communication port from over-voltage and overcurrent conditions between each signal line and ground.

10.10 Software

Furnish NTCIP compatible control/diagnostic software for the purpose of troubleshooting and testing. The software shall send requests and receive responses over any TCP/IP-based network for the functions of controlling DMS messaging, monitoring system status and performing DMS diagnostics (detecting failed pixels, display drivers, power supplies, alarm conditions, etc.).

For the details and definitions for the actual NTCIP communications protocols used to accomplish this, Section 9.0.

11.0 DMS System Type 2 – Full Size, Walk-In, Amber

11.1 General

Design and furnish a Light Emitting Diode (LED) Dynamic Message Sign providing a full matrix amber display for freeway traveler information applications. The DMS matrix shall be sized sufficient to provide display of three (3) rows of twenty-one (21) characters, with a nominal character size of 18-inches and a pixel pitch of between 1.30 to 1.35 inches. The sign shall provide walk-in access to all interior components.

Provide a fully debugged DMS system complete with all individual units, components, software modules, cabling, connectors etc. that are completely compatible with each other and are capable of being controlled by the current ATMS being operated at the Department TMC.

11.2 Housing/Enclosure

Design and furnish a DMS enclosure of a design and shape as to house all necessary display modules, display driver electronics, transformers, power supplies and other internal sign equipment.

Provide a weatherproof housing and internal equipment rated to withstand a humidity range of 0-99% non-condensing.

Construct enclosure of a corrosion resistant aluminum material conforming to the following:

1. Sheet aluminum shall be fabricated from aluminum alloy sheet meeting the requirements of ASTM B 209, Alloy 5052, Temper H3, or equivalent, minimum 0.125 inch thick. Cast aluminum shall be fabricated from aluminum alloy meeting the requirements of ASTM B 686, Alloy A 356 (A 13560) or equivalent. Flat cast surfaces exceeding 12 inches in both directions shall have a minimum thickness of 0.25 inches. Flat cast surfaces not exceeding 12 inches in both directions shall have a minimum thickness of 0.187 inches.
2. All DMS enclosures shall meet the requirements for TYPE 3R enclosures according to NEMA Standard Publication 250. All seams and openings shall be designed to prevent entry of water resulting from high pressure washing of the DMS enclosure.
3. Unpainted aluminum DMS enclosures shall be fabricated from mill-finish material and shall be cleaned using appropriate methods that will remove oil, film, weld black, and mill ink marks and render the surface clean, bright, smooth, and non-sticky to touch. Isolate all adjacent dissimilar materials, as approved by the Department.
4. All nuts and bolts used in the DMS assembly shall be stainless steel. All connecting surfaces shall be weatherproof and watertight when secured. All internal components shall be mounted so that there are no external protrusions.
5. The DMS shall be in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except as modified herein: The DMS enclosures shall be designed and constructed to present a clean, neat appearance and the equipment located inside shall be adequately protected from moisture, dust, dirt, corrosion, and excessive heat.

6. All surfaces shall be suitably protected from the weather. All corners and seams shall be heli-arc welded to provide a weatherproof seal around the entire case.
7. The DMS enclosure shall not be adversely affected by salt from the roadways or marine environments or chemicals or fumes discharged from nearby automobiles, industries and other sources. The interior of the DMS face window and the LEDs shall be easily accessible for cleaning and other maintenance.
8. Appropriate precautions, such as heating elements or ventilation fans or openings, shall be taken to ensure that condensation does not occur between the matrix elements and the DMS window face, and that the environment inside all enclosures remains within the temperature and humidity limits required for proper operation of the sign's electronic components.
9. Provide temperature sensor(s) in the DMS enclosure that is/are controlled and monitored by the DMS controller. Provide the capability for user defined critical thresholds to be established and changed remotely from the Department TMC or other location using the sign controller.
10. Provide humidity sensor(s) within the DMS enclosure that can detect relative humidity from 0%-100% in 1% or smaller increments. Provide an interface between the humidity sensor and the DMS controller which allows humidity levels to be monitored remotely from the TMC. Provide a sensor with an accuracy that exceeds 5% relative humidity.
11. All hinges used shall be continuous stainless steel, equipped with stainless steel hinge pins. Each hinge shall be secured with stainless steel bolts and lock nuts. The hinge pins and bolts shall be tamper proof.
12. The dead load shall consist of the total weight as installed of the DMS enclosure and appurtenances. The point of application of weights of the individual items shall be their representative centers of gravity.
13. Ice load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except that ice load shall be applied to all sides and top surfaces of the DMS enclosure simultaneously.
14. Wind load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals, except as modified herein: the enclosure and their mountings shall withstand a sustained wind speed of 90 miles per hour (mph), with a gust factor of 1.3.
15. Full 100 percent impact shall be used for handling and erection stress.

The DMS shall be capable of being mounted without gaining access to the inside of the enclosure. All mounting eyes shall be attached to the DMS enclosure structural framing.

Removal of any of the display modules or any other electronic or electrical component, shall not alter the structural integrity of the DMS display assembly or the DMS enclosure.

Opening door(s) shall allow maintenance personnel immediate access to circuit boards and internal sign parts, without having to remove any item in the sign, or the need to use any tools or to remove any device that could be dropped or lost, such as a locking pin or bolt. Each door shall be sealed to prevent the elements from entering, and shall have at least two locking points to keep unauthorized persons from accessing the interior of the DMS. In addition, each door shall be provided with rigid, telescopic, retention device, to keep the door in the open position. All doors, when in the open position,

shall not obstruct any portion of the opening. The door system shall pull the door tight and compress a gasket located around the perimeter. The gasket shall prevent water from entering the interior of the cabinet.

All serviceable components shall be modular, interchangeable and removable from within the DMS enclosure. The sign design shall allow unobstructed and convenient access to all serviceable components within the DMS enclosure and between the DMS display and the DMS display cover.

Drain holes shall be provided and designed to remove any condensation that may form inside the DMS enclosure and allow any water that may have collected in the housing to escape. All holes shall be screened to prevent small objects, insects and creatures from entering into the enclosure.

Heating, cooling and/or dehumidifying equipment shall be sized to maintain the internal DMS enclosure temperature within the operating ranges of the electric, electronic and mechanical equipment components. The environmental equipment shall have controls which shall shut down the DMS just prior to the temperature that the interior of the enclosure reaches the rated maximum operating temperature of the LEDs, and shall restore operation when the temperature has returned to safe operating levels. The shutdown shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

Electric ventilation fans shall be provided to generate positive pressure ventilation and shall be sized to provide 25 percent excess ventilation capacity, with one fan inoperative, over that required to maintain the DMS enclosure interior temperature within the range over which the DMS components can operate without failure or degradation, during full daylight heat gain conditions. All fans shall have ball or roller bearings. Fan operation and failure shall be reported to the DMS Central Processor via the communications protocol.

Louvered air inlets with removable, non-proprietary 500 micron, 2-stage filters and air deflector, sized to provide a maximum air intake velocity of 600 feet per minute with all fans operating. The direction of airflow and the filter characteristics (i.e., filter model number, type, dimensions, and particle size) shall be permanently engraved on each air vent. Exhaust air vents, if without filters, shall be screened to prevent small objects and creatures from entering into the enclosure.

11.3 LEDs

The LEDs that make up the display modules shall be high luminous intensity T-1 3/4" type manufactured by a reputable manufacturer. The LEDs shall have an ultraviolet light inhibitor in the epoxy dome package and be of a production type already tested for use in high vibration commercial traffic environments and climate of the mid-Atlantic United States.

Each DMS LED module shall be comprised of Amber LEDs that meet AlInGaP semiconductor technology that has a peak wavelength of 588-592nm.

All LEDs shall have a nominal viewing cone of 30 degrees with a half-power angle of 15 degrees measured from the longitudinal axis of the LED.

The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

The LEDs used in the display shall be obtained from batches sorted for luminous output, where the highest luminosity LED in the batch shall not be more than fifty percent more luminous than the lowest luminosity LED in the batch when operated at the manufacturer's recommended drive current. To ensure uniformity of display and operational life, all LEDs used to make up a display module shall be obtained from the same manufacturing batch.

The LED manufacturer shall perform intensity sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive luminous intensity "bins" as defined by the LED manufacturer.

The LED manufacturer shall perform color sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive color "bins" as defined by the LED manufacturer.

The LED mean time before failure (MTBF) shall be a minimum of 100,000 hours of elapsed time calendar hours use in an ambient temperature of 131 degrees Fahrenheit, based on an average daily on-time usage factor of 50%, when driven at the specific forward current recommended by the LED manufacturer for normal daylight DMS display operation. As part of the LED manufacturer's technical specification sheet submittal, the specific forward current shall be noted.

The statistical average long term light output degradation of the LEDs used in the display, operated at the LED manufacturer's recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure in an ambient temperature of 131 degrees Fahrenheit, shall not exceed the following:

1. A maximum of 10% reduction in light output after 10,000 hours of continuous on time.
2. A maximum of 25% reduction in light output after 50,000 hours of continuous on time.
3. A maximum of 30% reduction in light output after 100,000 hours of continuous on-time.
4. Manufacturer's documentation for high temperature operating life (HTOL) shall indicate if HTOL values are based upon actual or extrapolated data.

11.4 Display Modules

The LED display modules shall have a minimum refresh rate of 60 times per second to prevent visible flicker.

The LEDs shall be grouped in pixels consisting of discrete LEDs arranged in a continuous matrix display with individual pixel addressability. The centers of all pixels shall be arranged so as to maintain the same horizontal and vertical spacing between adjacent pixels. All pixels shall be replaceable. The LED grouping and mounting angle shall be optimized for maximum readability.

The electronics for the DMS shall be fully configured to drive the total required number of LEDs. The failure of any one pixel shall not affect the operation of any other pixel. The power driver circuitry shall be designed to minimize power consumption. Each LED display module shall have a diagnostic capability to detect a failure on the LED display module, down to the pixel level and report the failure to the DMS controller.

Removal of any display module shall not affect the operation of the remaining modules.

The LED modules shall be protected from degradation due to sunlight. The method used shall not obstruct the view of the display or reduce the viewing angle below that provided by an unprotected LED module. The method and design of the DMS sunlight protection shall be approved by the Department.

Each pixel shall contain an adequate number of discrete LEDs, based on a nominal pixel spacing of 1.30-1.35 inches, center to center, to meet the luminosity requirements herein.

Each discrete LED on the display module is driven at the LED manufacturer's recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure.

All DMS must be capable of meeting or exceeding the Manual of Uniform Traffic Control Devices (MUTCD) guidelines for inter-character and inter-line spacing of 25% and 50% of character height, respectively.

The 18" character of the Freeway DMS shall be clearly visible and legible from in-vehicle distance of 1,000 feet from the DMS face under clear daylight and nighttime conditions with the DMS face positioned in the roadway line of sight.

11.5 Dimming Circuitry

The DMS shall have a photocell controlled dimming circuit which shall automatically adjust the luminance of the LED display pixels in accordance with ambient light conditions. As part of the Proposer's submittal, a complete schematic of the LED display power, driver and dimming circuits shall be provided for approval by the Department.

Continuous current drive shall be used at the maximum brightness level. The current used for maximum brightness shall not exceed the current used to achieve the rated mean time before failure (MTBF). The current used for maximum brightness shall be indicated as part of the submittal.

For luminance levels less than maximum brightness, either continuous current drive or current pulse width modulation shall be used to dim the LEDs. If pulse width modulation is used, the dimming circuit shall be designed so that the maximum, instantaneous and average currents shall not exceed the rated peak and transient forward current ratings of the LEDs.

The DMS shall be equipped with a minimum of two external light sensors oriented in opposite directions and shall be scaled for up to 100,000 lux.

The LED dimming circuit shall also incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the LED current does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs the DMS shall blank-out, until the temperature has returned to safe operating levels.

The LED dimming circuit shall not cause the LED display to flicker as the temperature oscillates above and below the rated operating temperature of the LEDs.

11.6 Power Supply

The DMS shall be operated at a low internal DC voltage not exceeding 24 Volts.

The quantity of power supplies and current rating of each power supply shall be at least 25% spare capacity over that required to light every pixel of the DMS at full brightness.

The DMS and controller shall have redundant power supplies wired so that in the event of a failure of any one power supply, the second power supply shall automatically power that portion of the sign. Power supply failure shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

The power supplies shall be short circuit protected and shall reset automatically after 5 seconds of AC power off. The power supplies shall be protected by a suitable overcurrent protection device.

The power supply shall have an efficiency rating of 85%, minimum.

The operating temperature range of the power supply inside the DMS enclosure shall be negative 20 degrees Fahrenheit to 140 degrees Fahrenheit.

The power supply shall be UL listed.

11.7 Controller

The DMS controller shall be a microprocessor-based unit with sufficient on-board memory and input and output interfaces to provide all the functions required by this Section.

The DMS controller shall accommodate both local and remote control from multiple host devices as described herein. Local control shall be supported from a locally connected sign programmer. Remote control shall be supported from a remotely located DMS Central Processor (control computer system).

The DMS controller shall receive and interpret commands sent by the host device to either configure the DMS or cause a requested message to be displayed on the DMS. Based on the command, the DMS Controller shall provide return data to the host device to provide information about the status of the sign.

The DMS controller shall be capable of simultaneously receiving commands from and transmitting status data to multiple host devices; i.e., the sign programmer, local control panel and the DMS Central Processor.

The method of control of the DMS shall be dependent upon the setting of the Control Mode Selector switch in each local control panel. This switch shall allow for two modes of operation:

"Remote" mode: This is the normal mode of operation of the DMS, where all control is from a remote DMS Central Processor, via NTCIP data exchanged directly between the remote DMS Central Processor and the DMS controller.

"Local" mode: When the Control Mode Selector switch is in this position, control from the remote DMS Central Processor shall be disabled and the DMS shall be controlled in accordance with commands entered via the message selector switch on the Local Control Panel or a NTCIP data exchanged directly with a locally connected Sign Programmer. When in "local" mode, the remote DMS Central Processor shall still be able to monitor the status of the DMS.

When switching from one mode to another, the DMS shall continue to display its current message, until it receives a command to display another message, from either the remote DMS Central Processor or the local controls, as applicable.

A change of position of the mode selector switch shall be immediately reported to the DMS Central Processor in the form of an alarm, and shall be logged internally at the site CPU for retrieval on the next polling cycle, and in accordance with the communications protocol.

Each DMS controller shall have error detection and reporting features which shall be utilized to guard against incomplete or incorrect information transmission, message generation and display on the DMS, as well as provide capability to detect a failure down to a replaceable component and report the failure and failed component. All errors and hardware failures shall be logged and reported to the DMS Central Processor or Sign Programmer (if connected) via the communications protocol. The DMS controller shall have the capability to automatically recover from failure conditions when the failure conditions are corrected or the failures are no longer present, and report the restored operation of the DMS to the DMS Central Processor or Sign Programmer (if connected).

The DMS controller shall have diagnostic capabilities features to:

1. Perform redundant checking of all data received and transmitted, and incorporate cyclic redundancy check (CRC) error detection logic, as specified by the NTCIP standards.
2. Validate the content of all received transmissions.
3. Check and report logic or data errors.
4. Monitor status for communication line malfunction or break.
5. Respond to system polling from the DMS Central Processor.
6. Check and report errors in display driver operation.
7. Check and report the failure and location of bad pixels.
8. Check and report the failure of bad fans.
9. Check and report whether the controller cabinet or DMS enclosure door is open or closed.
10. Check the operation and report the failure and location of bad power supplies.
11. Check the duration of power failures.
12. Check and report the number of occurrences the watchdog timer resets the controller.

Whenever any of the following error or failure conditions is detected, the DMS controller shall blank the DMS and shall include the error or failure in the return message:

1. The number of pixels that are not working for the particular sign type exceed a specified maximum value. The Proposer shall determine this number for each sign type and have these numbers approved by the Department.

2. The ratio of the number of pixels that achieve a commanded state divided by the number of pixels commanded to that state exceeds a legibility threshold value. The test shall include only those pixels that are contained in the character positions of the message text.
3. Communication loss greater than a configurable time value measured in minutes. The default value shall be 10 minutes. If a system poll is not received within a configurable threshold period, the controller shall blank all signs connected to it. The configuration of system polling shall also have an option for disabling this feature.
4. Upon detection of a power failure to the DMS controller or the DMS display(s) connected to the controller, the current message displayed on the DMS just prior to the power failure shall be retained in memory.
5. Upon power restoration, the DMS shall remain blank if the duration of the power failure exceeded the configurable long term power failure duration threshold, else the previous message shall be restored to its respective DMS. The default value of the long term power failure duration threshold shall be 10 minutes.
6. Overheating condition in DMS enclosure: The LED dimming circuit shall also incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the it does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs, the DMS shall blank-out until the temperature has returned to safe operating levels.
7. Information on each of the specific failures shall be sent to the DMS Central Processor.

Each DMS controller shall have the capability of displaying messages transmitted directly from a DMS Central Processor or Sign Programmer in addition to displaying locally commanded messages from a pre-programmed local message library. Each sign's local message library shall have the capacity to store a minimum of 256 display messages with related display attributes for each message, such as flashing rate and percent "on" time. The local message library shall consist of:

1. A "changeable, non-volatile" local message library stored in battery-backed RAM. The changeable local message library shall be programmable through both the DMS Central Processor and the Sign Programmer.
2. A "permanent, non-volatile" local message library, stored on EPROM shall be provided. Battery-backed RAM memory shall not be acceptable. If a microprocessor-based controller is used, then EEPROM, flash RAM or similar technology memory devices, programmed as described herein, may be used to store the message library.

Each DMS controller shall write messages on the DMS at a minimum rate of 300 characters per second.

Each DMS controller shall have an easily accessible and clearly labeled ON/OFF switch. When in the "OFF" position all power shall be disconnected from the DMS control electronics and matrix units and the DMS shall blank-out.

The Proposer shall provide a means of establishing a monetary reset switch on the DMS controller. The contact switch shall reset the DMS controller when depressed. Operation of the momentary contact switch shall not require the user to hold the switch in the depressed position for more than 0.25 seconds.

The DMS controller shall interface and communicate with one or more Operator Interfaces, as indicated on the Contract Drawings. Operator Interfaces and associated functions shall be as described elsewhere herein.

The DMS controller shall be provided with all software and hardware required to perform the following functions:

1. Password protection to restrict access to control and configuration functions.
2. Fully programmable parameters for all functions described in this section.
3. Real-time clock and calendar for timing and scheduling of automatic functions. The calendar shall automatically adjust itself for leap years, and for changeover from Standard to Daylight savings time and back.
4. Variable message flash rate and percent "on" time.
    a. Flash rate shall be adjustable in one-tenth second increments.
    b. Percent "on" time shall be adjustable from 0 to 9.9 seconds, in one-tenth second increments.
5. Multi-page messages with variable page display times that are adjustable in one-tenth second increments from 0 to 15.0 seconds.
6. Negative text inversion (or inverse/reverse video) - switch between illuminated text on a dark background or dark text on an illuminated background. Inverse/reverse video shall be implemented with the use of standard NTCIP foreground and background objects.
7. Configurable line justification (center, left or right) with center justification as the default setting.
8. Configurable page justification (top, center, bottom) with center justification as the default setting.
9. Configurable message duration parameter, to specify how long the current message should remain displayed regardless of the status of the communications with the DMS Central Processor.
10. Communications Loss message threshold, to specify how long the current message should remain displayed in the absence of communications with the DMS Central Processor.
11. Control of pixel luminance levels, both directly and based on ambient light levels obtained from the photocells. Luminance levels shall be stored in the DMS controller and shall be adjustable, in a range of 0 to 255, on either a continuous logarithmic basis, to match the normal human eye luminous response characteristic, or a 1/2 incremental dimming basis, where each lower dimming level is 1/2 the previous level.
12. Monitoring of each pixel of the DMS.
13. Monitoring of power failures: When a power failure is detected, the displayed message shall be retained in memory. If power to the DMS controller is restored within a configurable period of time, the last displayed message shall be restored. If the duration of the power failure exceeds the configured period of time, the DMS shall remain blank, until a command to display a message is received. Upon restoration of power, the DMS controller shall report the occurrence, time and duration of the power failure, to the DMS Central Processor or Sign Programmer, if connected.
14. Hardware watchdog timer: The DMS controller shall have a hardware watchdog timer that shall check for a stall condition in the controller hardware, software or firmware. While the

DMS controller is powered on, the software shall poll the watchdog timer. Upon reset, the watchdog timer shall initialize its timing circuit. If the watchdog timing circuit times out without being reset by the software, the watchdog counter shall be incremented and the watchdog shall reset the controller to clear a potential stall condition from the hardware, software or firmware and send an error message to the DMS Central Processor or Sign Programmer (if connected) to advise of the condition. The number of occurrences that the watchdog timer resets the controller shall be transmitted to the DMS Central Processor or Sign Programmer (if connected) upon request and then cleared.

15. Programmable Font Sets: The DMS controller shall support multiple programmable font sets. At a minimum, this should include fonts for 6", 9", 12", and 18" character heights, variable and fixed width fonts, and single, double, and triple stroke fonts. Each font set shall be capable of being programmed from the DMS Central Processor or the Sign Programmer if connected. Additional font sets may be provided at no additional cost and will be considered as additional value added to the proposal.
16. Each font set shall include, but not be limited to, all upper case letters, numerals, punctuation marks and arrows that are displayed in each of the eight cardinal directions.
17. Customizable and Standard Graphics Library: Provide a suite of pre-generated MUTCD style symbols, along with the ability to modify or create independent symbols, saving of new graphics and editing. The library should hold a minimum of 50 graphics.
18. The DMS controller shall keep a log of all system errors, malfunctions, automatic operations and locally controlled commands and activities. All logs shall be time and date stamped. The DMS controller shall have sufficient memory to store a minimum of 500 log entries. If 100% of the log storage memory has been reached without a successful download to the DMS Central Processor or a Sign Programmer, the oldest log entry shall be overwritten. The DMS controller shall download all log entries to a DMS Central Processor or Sign Programmer, upon user request from one of these devices and clear the log.

11.8 Controller Cabinet

All DMS controller cabinets will be furnished and installed by DelDOT's Traffic Signal/ITS Construction Contractor. Coordinate with DelDOT to confirm size, layout, power supply, and mounting/orientation of DMS controller cabinets prior to executing each individual purchase order.

11.9 Communications

Provide layout space for a cellular modem and antenna, Ethernet network switches, and/or 4.9GHz communications network equipment.

The DMS controller shall have a minimum of two (2) serial data and one (1) Ethernet communications ports to facilitate simultaneous communications for local and remote control, programming, and diagnostics.

When connected to a serial port, the DMS shall automatically use the NTCIP communications stack associated with serial communications, i.e., NTCIP 2101, NTCIP 2201, and NTCIP 2301.

When connected to the Ethernet port, the DMS shall automatically use the NTCIP communications stack associated with Ethernet communications, i.e., NTCIP 2104, NTCIP 2202, and NTCIP 2301. All ports shall be configurable such that:

3. Communications with the serial ports shall support all typical serial baud rates ranging from 1200 to 115,200 baud.
4. Communications with the Ethernet port shall be capable of communicating via TCP/IP or UDP/IP at 10 or 100 MB.

The serial ports in the DMS sign controller shall be protected with surge protection to protect the modem communication port from over-voltage and overcurrent conditions between each signal line and ground.

11.10 Software

Furnish NTCIP compatible control/diagnostic software for the purpose of troubleshooting and testing. The software shall send requests and receive responses over any TCP/IP-based network for the functions of controlling DMS messaging, monitoring system status and performing DMS diagnostics (detecting failed pixels, display drivers, power supplies, alarm conditions, etc.).

For the details and definitions for the actual NTCIP communications protocols used to accomplish this, Section 9.0.

12.0 DMS System Type 3 – Medium Size, Front Access, Color

12.1 General

Design and furnish a Light Emitting Diode (LED) Dynamic Message Sign providing a full matrix color display for freeway traveler information applications. The DMS matrix shall be sized sufficient to provide display of three (3) rows of fifteen (15) characters, with a nominal character size of 18-inches and a pixel pitch of between 0.79 to 0.81 inches. The sign shall provide front access to all interior components.

Provide a fully debugged DMS system complete with all individual units, components, software modules, cabling, connectors etc. that are completely compatible with each other and are capable of being controlled by the current ATMS being operated at the Department TMC.

12.2 Housing/Enclosure

Design and furnish a DMS enclosure of a design and shape as to house all necessary display modules, display driver electronics, transformers, power supplies and other internal sign equipment.

Provide a weatherproof housing and internal equipment rated to withstand a humidity range of 0-99% non-condensing.

Construct enclosure of a corrosion resistant aluminum material conforming to the following:

1. Sheet aluminum shall be fabricated from aluminum alloy sheet meeting the requirements of ASTM B 209, Alloy 5052, Temper H3, or equivalent, minimum 0.125 inch thick. Cast aluminum shall be fabricated from aluminum alloy meeting the requirements of ASTM B 686, Alloy A 356 (A 13560) or equivalent. Flat cast surfaces exceeding 12 inches in both directions shall have a minimum thickness of 0.25 inches. Flat cast surfaces not exceeding 12 inches in both directions shall have a minimum thickness of 0.187 inches.
2. All DMS enclosures shall meet the requirements for TYPE 3R enclosures according to NEMA Standard Publication 250. All seams and openings shall be designed to prevent entry of water resulting from high pressure washing of the DMS enclosure.
3. Unpainted aluminum DMS enclosures shall be fabricated from mill-finish material and shall be cleaned using appropriate methods that will remove oil, film, weld black, and mill ink marks and render the surface clean, bright, smooth, and non-sticky to touch. Isolate all adjacent dissimilar materials, as approved by the Department.
4. All nuts and bolts used in the DMS assembly shall be stainless steel. All connecting surfaces shall be weatherproof and watertight when secured. All internal components shall be mounted so that there are no external protrusions.
5. The DMS shall be in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except as modified herein: The DMS enclosures shall be designed and constructed to present a clean, neat appearance and the equipment located inside shall be adequately protected from moisture, dust, dirt, corrosion, and excessive heat.

6. All surfaces shall be suitably protected from the weather. All corners and seams shall be heli-arc welded to provide a weatherproof seal around the entire case.
7. The DMS enclosure shall not be adversely affected by salt from the roadways or marine environments or chemicals or fumes discharged from nearby automobiles, industries and other sources. The interior of the DMS face window and the LEDs shall be easily accessible for cleaning and other maintenance.
8. Appropriate precautions, such as heating elements or ventilation fans or openings, shall be taken to ensure that condensation does not occur between the matrix elements and the DMS window face, and that the environment inside all enclosures remains within the temperature and humidity limits required for proper operation of the sign's electronic components.
9. Provide temperature sensor(s) in the DMS enclosure that is/are controlled and monitored by the DMS controller. Provide the capability for user defined critical thresholds to be established and changed remotely from the Department TMC or other location using the sign controller.
10. Provide humidity sensor(s) within the DMS enclosure that can detect relative humidity from 0%-100% in 1% or smaller increments. Provide an interface between the humidity sensor and the DMS controller which allows humidity levels to be monitored remotely from the TMC. Provide a sensor with an accuracy that exceeds 5% relative humidity.
11. All hinges used shall be continuous stainless steel, equipped with stainless steel hinge pins. Each hinge shall be secured with stainless steel bolts and lock nuts. The hinge pins and bolts shall be tamper proof.
12. The dead load shall consist of the total weight as installed of the DMS enclosure and appurtenances. The point of application of weights of the individual items shall be their representative centers of gravity.
13. Ice load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except that ice load shall be applied to all sides and top surfaces of the DMS enclosure simultaneously.
14. Wind load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals, except as modified herein: the enclosure and their mountings shall withstand a sustained wind speed of 90 miles per hour (mph), with a gust factor of 1.3.
15. Full 100 percent impact shall be used for handling and erection stress.

The DMS shall be capable of being mounted without gaining access to the inside of the enclosure. All mounting eyes shall be attached to the DMS enclosure structural framing.

Removal of any of the display modules or any other electronic or electrical component, shall not alter the structural integrity of the DMS display assembly or the DMS enclosure.

Access opening shall allow maintenance personnel immediate access to circuit boards and internal sign parts, without having to remove any item in the sign, or the need to use any tools or to remove any device that could be dropped or lost, such as a locking pin or bolt. Each opening shall be sealed to prevent the elements from entering, and shall have at least two locking points to keep unauthorized persons from accessing the interior of the DMS. In addition, each opening shall be provided with rigid,

telescopic, retention device, to keep the panel in the open position. All panels, when in the open position, shall not obstruct any portion of the opening. The opening system shall pull the panel tight and compress a gasket located around the perimeter. The gasket shall prevent water from entering the interior of the cabinet.

All serviceable components shall be modular, interchangeable and removable from within the DMS enclosure. The sign design shall allow unobstructed and convenient access to all serviceable components within the DMS enclosure and between the DMS display and the DMS display cover.

Drain holes shall be provided and designed to remove any condensation that may form inside the DMS enclosure and allow any water that may have collected in the housing to escape. All holes shall be screened to prevent small objects, insects and creatures from entering into the enclosure.

Heating, cooling and/or dehumidifying equipment shall be sized to maintain the internal DMS enclosure temperature within the operating ranges of the electric, electronic and mechanical equipment components. The environmental equipment shall have controls which shall shut down the DMS just prior to the temperature that the interior of the enclosure reaches the rated maximum operating temperature of the LEDs, and shall restore operation when the temperature has returned to safe operating levels. The shutdown shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

Electric ventilation fans shall be provided to generate positive pressure ventilation and shall be sized to provide 25 percent excess ventilation capacity, with one fan inoperative, over that required to maintain the DMS enclosure interior temperature within the range over which the DMS components can operate without failure or degradation, during full daylight heat gain conditions. All fans shall have ball or roller bearings. Fan operation and failure shall be reported to the DMS Central Processor via the communications protocol.

Louvered air inlets with removable, non-proprietary 500 micron, 2-stage filters and air deflector, sized to provide a maximum air intake velocity of 600 feet per minute with all fans operating. The direction of airflow and the filter characteristics (i.e., filter model number, type, dimensions, and particle size) shall be permanently engraved on each air vent. Exhaust air vents, if without filters, shall be screened to prevent small objects and creatures from entering into the enclosure.

A vent-free DMS housing for front access devices will be considered if satisfactory evidence of proper operation is supplied with the technical submittal, including factory or third-party certification. Vent-free design shall ensure that the DMS enclosure interior temperature does not exceed the maximum range of the DMS components to ensure continued operation without failure or degradation, particularly during full daylight heat gain.

12.3 LEDs

The LEDs that make up the display modules shall be high luminous intensity T-1 3/4" type manufactured by a reputable manufacturer. The LEDs shall have an ultraviolet light inhibitor in the epoxy dome package and be of a production type already tested for use in high vibration commercial traffic environments and climate of the northeastern United States.

Each Full-color DMS LED module shall be comprised of Red Green and Blue LEDs that meet the following specifications:

1. Red LEDs shall utilize AlInGaP semiconductor technology and shall emit red light that has a peak wavelength of 615-635nm.
2. Green LEDs shall utilize InGaN semiconductor technology and shall emit green light that has a peak wavelength of 520-535nm.
3. Blue LEDs shall utilize InGaN semiconductor technology and shall emit blue light that has a peak wavelength of 464-475nm.

All LEDs shall have a nominal viewing cone of 30 degrees with a half-power angle of 15 degrees measured from the longitudinal axis of the LED.

The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

The LEDs used in the display shall be obtained from batches sorted for luminous output, where the highest luminosity LED in the batch shall not be more than fifty percent more luminous than the lowest luminosity LED in the batch when operated at the manufacturer's recommended drive current. To ensure uniformity of display and operational life, all LEDs used to make up a display module shall be obtained from the same manufacturing batch.

The LED manufacturer shall perform intensity sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive luminous intensity "bins" as defined by the LED manufacturer.

The LED manufacturer shall perform color sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive color "bins" as defined by the LED manufacturer.

The LED mean time before failure (MTBF) shall be a minimum of 100,000 hours of elapsed time calendar hours use in an ambient temperature of 131 degrees Fahrenheit, based on an average daily on-time usage factor of 50%, when driven at the specific forward current recommended by the LED manufacturer for normal daylight DMS display operation. As part of the LED manufacturer's technical specification sheet submittal, the specific forward current shall be noted.

The statistical average long term light output degradation of the LEDs used in the display, operated at the LED manufacturer's recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure in an ambient temperature of 131 degrees Fahrenheit, shall not exceed the following:

1. A maximum of 10% reduction in light output after 10,000 hours of continuous on time.
2. A maximum of 25% reduction in light output after 50,000 hours of continuous on time.
3. A maximum of 30% reduction in light output after 100,000 hours of continuous on-time.
4. Manufacturer's documentation for high temperature operating life (HTOL) shall indicate if HTOL values are based upon actual or extrapolated data.

12.4 Display Modules

The LED display modules shall have a minimum refresh rate of 60 times per second to prevent visible flicker.

The LEDs shall be grouped in pixels consisting of discrete LEDs arranged in a continuous matrix display with individual pixel addressability. The centers of all pixels shall be arranged so as to maintain the same horizontal and vertical spacing between adjacent pixels. All pixels shall be replaceable. The LED grouping and mounting angle shall be optimized for maximum readability.

The electronics for the DMS shall be fully configured to drive the total required number of LEDs. The failure of any one pixel shall not affect the operation of any other pixel. The power driver circuitry shall be designed to minimize power consumption. Each LED display module shall have a diagnostic capability to detect a failure on the LED display module, down to the pixel level and report the failure to the DMS controller.

Removal of any display module shall not affect the operation of the remaining modules.

The LED modules shall be protected from degradation due to sunlight. The method used shall not obstruct the view of the display or reduce the viewing angle below that provided by an unprotected LED module. The method and design of the DMS sunlight protection shall be approved by the Department.

Each pixel shall contain an adequate number of discrete LEDs, based on a nominal pixel spacing of 0.79 to 0.81 inches, center to center, to meet the luminosity requirements herein.

Each discrete LED on the display module is driven at the LED manufacturer’s recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure.

All DMS must be capable of meeting or exceeding the Manual of Uniform Traffic Control Devices (MUTCD) guidelines for inter-character and inter-line spacing of 25% and 50% of character height, respectively.

The 18” character of the Freeway DMS shall be clearly visible and legible from in-vehicle distance of 1,000 feet from the DMS face under clear daylight and nighttime conditions with the DMS face positioned in the roadway line of sight.

12.5 Dimming Circuitry

The DMS shall have a photocell controlled dimming circuit which shall automatically adjust the luminance of the LED display pixels in accordance with ambient light conditions. As part of the Proposer's submittal, a complete schematic of the LED display power, driver and dimming circuits shall be provided for approval by the Department.

Continuous current drive shall be used at the maximum brightness level. The current used for maximum brightness shall not exceed the current used to achieve the rated mean time before failure (MTBF). The current used for maximum brightness shall be indicated as part of the submittal.

For luminance levels less than maximum brightness, either continuous current drive or current pulse width modulation shall be used to dim the LEDs. If pulse width modulation is used, the dimming

circuit shall be designed so that the maximum, instantaneous and average currents shall not exceed the rated peak and transient forward current ratings of the LEDs.

The DMS shall be equipped with a minimum of two external light sensors oriented in opposite directions and shall be scaled for up to 100,000 lux.

The LED dimming circuit shall also incorporate temperature-controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the LED current does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs the DMS shall blank-out, until the temperature has returned to safe operating levels.

The LED dimming circuit shall not cause the LED display to flicker as the temperature oscillates above and below the rated operating temperature of the LEDs.

12.6 Power Supply

The DMS shall be operated at a low internal DC voltage not exceeding 24 Volts.

The quantity of power supplies and current rating of each power supply shall be at least 25% spare capacity over that required to light every pixel of the DMS at full brightness.

The DMS and controller shall have redundant power supplies wired so that in the event of a failure of any one power supply, the second power supply shall automatically power that portion of the sign. Power supply failure shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

The power supplies shall be short circuit protected and shall reset automatically after 5 seconds of AC power off. The power supplies shall be protected by a suitable overcurrent protection device.

The power supply shall have an efficiency rating of 85%, minimum.

The operating temperature range of the power supply inside the DMS enclosure shall be negative 20 degrees Fahrenheit to 140 degrees Fahrenheit.

The power supply shall be UL listed.

12.7 Controller

The DMS controller shall be a microprocessor-based unit with sufficient on-board memory and input and output interfaces to provide all the functions required by this Section.

The DMS controller shall accommodate both local and remote control from multiple host devices as described herein. Local control shall be supported from a locally connected sign programmer. Remote control shall be supported from a remotely located DMS Central Processor (control computer system).

The DMS controller shall receive and interpret commands sent by the host device to either configure the DMS or cause a requested message to be displayed on the DMS. Based on the command, the DMS

Controller shall provide return data to the host device to provide information about the status of the sign.

The DMS controller shall be capable of simultaneously receiving commands from and transmitting status data to multiple host devices; i.e., the sign programmer, local control panel and the DMS Central Processor.

The method of control of the DMS shall be dependent upon the setting of the Control Mode Selector switch in each local control panel. This switch shall allow for two modes of operation:

"Remote" mode: This is the normal mode of operation of the DMS, where all control is from a remote DMS Central Processor, via NTCIP data exchanged directly between the remote DMS Central Processor and the DMS controller.

"Local" mode: When the Control Mode Selector switch is in this position, control from the remote DMS Central Processor shall be disabled and the DMS shall be controlled in accordance with commands entered via the message selector switch on the Local Control Panel or a NTCIP data exchanged directly with a locally connected Sign Programmer. When in "local" mode, the remote DMS Central Processor shall still be able to monitor the status of the DMS.

When switching from one mode to another, the DMS shall continue to display its current message, until it receives a command to display another message, from either the remote DMS Central Processor or the local controls, as applicable.

A change of position of the mode selector switch shall be immediately reported to the DMS Central Processor in the form of an alarm, and shall be logged internally at the site CPU for retrieval on the next polling cycle, and in accordance with the communications protocol.

Each DMS controller shall have error detection and reporting features which shall be utilized to guard against incomplete or incorrect information transmission, message generation and display on the DMS, as well as provide capability to detect a failure down to a replaceable component and report the failure and failed component. All errors and hardware failures shall be logged and reported to the DMS Central Processor or Sign Programmer (if connected) via the communications protocol. The DMS controller shall have the capability to automatically recover from failure conditions when the failure conditions are corrected or the failures are no longer present, and report the restored operation of the DMS to the DMS Central Processor or Sign Programmer (if connected).

The DMS controller shall have diagnostic capabilities features to:

1. Perform redundant checking of all data received and transmitted, and incorporate cyclic redundancy check (CRC) error detection logic, as specified by the NTCIP standards.
2. Validate the content of all received transmissions.
3. Check and report logic or data errors.
4. Monitor status for communication line malfunction or break.
5. Respond to system polling from the DMS Central Processor.
6. Check and report errors in display driver operation.
7. Check and report the failure and location of bad pixels.

8. Check and report the failure of bad fans.
9. Check and report whether the controller cabinet or DMS enclosure door is open or closed.
10. Check the operation and report the failure and location of bad power supplies.
11. Check the duration of power failures.
12. Check and report the number of occurrences the watchdog timer resets the controller.

Whenever any of the following error or failure conditions is detected, the DMS controller shall blank the DMS and shall include the error or failure in the return message:

1. The number of pixels that are not working for the particular sign type exceed a specified maximum value. The Proposer shall determine this number for each sign type and have these numbers approved by the Department.
2. The ratio of the number of pixels that achieve a commanded state divided by the number of pixels commanded to that state exceeds a legibility threshold value. The test shall include only those pixels that are contained in the character positions of the message text.
3. Communication loss greater than a configurable time value measured in minutes. The default value shall be 10 minutes. If a system poll is not received within a configurable threshold period, the controller shall blank all signs connected to it. The configuration of system polling shall also have an option for disabling this feature.
4. Upon detection of a power failure to the DMS controller or the DMS display(s) connected to the controller, the current message displayed on the DMS just prior to the power failure shall be retained in memory.
5. Upon power restoration, the DMS shall remain blank if the duration of the power failure exceeded the configurable long term power failure duration threshold, else the previous message shall be restored to its respective DMS. The default value of the long term power failure duration threshold shall be 10 minutes.
6. Overheating condition in DMS enclosure: The LED dimming circuit shall also incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the it does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs, the DMS shall blank-out until the temperature has returned to safe operating levels.
7. Information on each of the specific failures shall be sent to the DMS Central Processor.

Each DMS controller shall have the capability of displaying messages transmitted directly from a DMS Central Processor or Sign Programmer in addition to displaying locally commanded messages from a pre-programmed local message library. Each sign's local message library shall have the capacity to store a minimum of 256 display messages with related display attributes for each message, such as flashing rate and percent "on" time. The local message library shall consist of:

1. A "changeable, non-volatile" local message library stored in battery-backed RAM. The changeable local message library shall be programmable through both the DMS Central Processor and the Sign Programmer.
2. A "permanent, non-volatile" local message library, stored on EPROM shall be provided. Battery-backed RAM memory shall not be acceptable. If a microprocessor-based controller is

used, then EEPROM, flash RAM or similar technology memory devices, programmed as described herein, may be used to store the message library.

Each DMS controller shall write messages on the DMS at a minimum rate of 300 characters per second.

Each DMS controller shall have an easily accessible and clearly labeled ON/OFF switch. When in the "OFF" position all power shall be disconnected from the DMS control electronics and matrix units and the DMS shall blank-out.

The Proposer shall provide a means of establishing a monetary reset switch on the DMS controller. The contact switch shall reset the DMS controller when depressed. Operation of the momentary contact switch shall not require the user to hold the switch in the depressed position for more than 0.25 seconds.

The DMS controller shall interface and communicate with one or more Operator Interfaces, as indicated on the Contract Drawings. Operator Interfaces and associated functions shall be as described elsewhere herein.

The DMS controller shall be provided with all software and hardware required to perform the following functions:

1. Password protection to restrict access to control and configuration functions.
2. Fully programmable parameters for all functions described in this section.
3. Real-time clock and calendar for timing and scheduling of automatic functions. The calendar shall automatically adjust itself for leap years, and for changeover from Standard to Daylight savings time and back.
4. Variable message flash rate and percent "on" time.
    a. Flash rate shall be adjustable in one-tenth second increments.
    b. Percent "on" time shall be adjustable from 0 to 9.9 seconds, in one-tenth second increments.
5. Multi-page messages with variable page display times that are adjustable in one-tenth second increments from 0 to 15.0 seconds.
6. Negative text inversion (or inverse/reverse video) - switch between illuminated text on a dark background or dark text on an illuminated background. Inverse/reverse video shall be implemented with the use of standard NTCIP foreground and background objects.
7. Configurable line justification (center, left or right) with center justification as the default setting.
8. Configurable page justification (top, center, bottom) with center justification as the default setting.
9. Configurable message duration parameter, to specify how long the current message should remain displayed regardless of the status of the communications with the DMS Central Processor.
10. Communications Loss message threshold, to specify how long the current message should remain displayed in the absence of communications with the DMS Central Processor.

11. Control of pixel luminance levels, both directly and based on ambient light levels obtained from the photocells. Luminance levels shall be stored in the DMS controller and shall be adjustable, in a range of 0 to 255, on either a continuous logarithmic basis, to match the normal human eye luminous response characteristic, or a 1/2 incremental dimming basis, where each lower dimming level is 1/2 the previous level.
12. Monitoring of each pixel of the DMS.
13. Monitoring of power failures: When a power failure is detected, the displayed message shall be retained in memory. If power to the DMS controller is restored within a configurable period of time, the last displayed message shall be restored. If the duration of the power failure exceeds the configured period of time, the DMS shall remain blank, until a command to display a message is received. Upon restoration of power, the DMS controller shall report the occurrence, time and duration of the power failure, to the DMS Central Processor or Sign Programmer, if connected.
14. Hardware watchdog timer: The DMS controller shall have a hardware watchdog timer that shall check for a stall condition in the controller hardware, software or firmware. While the DMS controller is powered on, the software shall poll the watchdog timer. Upon reset, the watchdog timer shall initialize its timing circuit. If the watchdog timing circuit times out without being reset by the software, the watchdog counter shall be incremented and the watchdog shall reset the controller to clear a potential stall condition from the hardware, software or firmware and send an error message to the DMS Central Processor or Sign Programmer (if connected) to advise of the condition. The number of occurrences that the watchdog timer resets the controller shall be transmitted to the DMS Central Processor or Sign Programmer (if connected) upon request and then cleared.
15. Programmable Font Sets: The DMS controller shall support multiple programmable font sets. At a minimum, this should include fonts for 6”, 9”, 12”, and 18” character heights, variable and fixed width fonts, and single, double, and triple stroke fonts. Each font set shall be capable of being programmed from the DMS Central Processor or the Sign Programmer if connected. Three of the font sets shall look like the E-modified font set defined by the MUTCD, replicating the appearance of the font used on some static signage on the DMS. A single, double and triple stroke E-modified font shall be provided. Additional font sets may be provided at no additional cost and will be considered as additional value added to the proposal.
16. Each font set shall include, but not be limited to, all upper case letters, numerals, punctuation marks and arrows that are displayed in each of the eight cardinal directions.
17. Customizable and Standard Graphics Library: Provide a suite of pre-generated MUTCD style symbols, along with the ability to modify or create independent symbols, saving of new graphics and color editing. The library should hold a minimum of 50 graphics.
18. The DMS controller shall keep a log of all system errors, malfunctions, automatic operations and locally controlled commands and activities. All logs shall be time and date stamped. The DMS controller shall have sufficient memory to store a minimum of 500 log entries. If 100% of the log storage memory has been reached without a successful download to the DMS Central Processor or a Sign Programmer, the oldest log entry shall be overwritten. The DMS controller shall download all log entries to a DMS Central Processor or Sign Programmer, upon user request from one of these devices and clear the log.

19. The DMS and Controller shall be capable of displaying a minimum of 256 different colors. DMS Controller shall be capable of displaying colors that conform to MUTCD requirements.

12.8 Controller Cabinet

All DMS controller cabinets will be furnished and installed by DelDOT's Traffic Signal/ITS Construction Contractor. Coordinate with DelDOT to confirm size, layout, power supply, and mounting/orientation of DMS controller cabinets prior to executing each individual purchase order.

12.9 Communications

Provide layout space for a cellular modem and antenna, Ethernet network switches, and/or 4.9GHz communications network equipment.

The DMS controller shall have a minimum of two (2) serial data and one (1) Ethernet communications ports to facilitate simultaneous communications for local and remote control, programming, and diagnostics.

When connected to a serial port, the DMS shall automatically use the NTCIP communications stack associated with serial communications, i.e., NTCIP 2101, NTCIP 2201, and NTCIP 2301.

When connected to the Ethernet port, the DMS shall automatically use the NTCIP communications stack associated with Ethernet communications, i.e., NTCIP 2104, NTCIP 2202, and NTCIP 2301. All ports shall be configurable such that:

1. Communications with the serial ports shall support all typical serial baud rates ranging from 1200 to 115,200 baud.
2. Communications with the Ethernet port shall be capable of communicating via TCP/IP or UDP/IP at 10 or 100 MB.

12.10 The serial ports in the DMS sign controller shall be protected with surge protection to protect the modem communication port from over-voltage and overcurrent conditions between each signal line and ground.

~~12.0~~

~~12.1~~12.11 Software

Furnish NTCIP compatible control/diagnostic software for the purpose of troubleshooting and testing. The software shall send requests and receive responses over any TCP/IP-based network for the functions of controlling DMS messaging, monitoring system status and performing DMS diagnostics (detecting failed pixels, display drivers, power supplies, alarm conditions, etc.).

For the details and definitions for the actual NTCIP communications protocols used to accomplish this, Section 9.0.

13.0 DMS System Type 4 – Medium Size, Front Access, Amber

13.1 General

Design and furnish a Light Emitting Diode (LED) Dynamic Message Sign providing a full matrix amber display for freeway traveler information applications. The DMS matrix shall be sized sufficient to provide display of three (3) rows of fifteen (15) characters, with a nominal character size of 18-inches and a pixel pitch of between 1.30 to 1.35 inches. The sign shall provide front access to all interior components.

Provide a fully debugged DMS system complete with all individual units, components, software modules, cabling, connectors etc. that are completely compatible with each other and are capable of being controlled by the current ATMS being operated at the Department TMC.

13.2 Housing/Enclosure

Design and furnish a DMS enclosure of a design and shape as to house all necessary display modules, display driver electronics, transformers, power supplies and other internal sign equipment.

Provide a weatherproof housing and internal equipment rated to withstand a humidity range of 0-99% non-condensing.

Construct enclosure of a corrosion resistant aluminum material conforming to the following:

1. Sheet aluminum shall be fabricated from aluminum alloy sheet meeting the requirements of ASTM B 209, Alloy 5052, Temper H3, or equivalent, minimum 0.125 inch thick. Cast aluminum shall be fabricated from aluminum alloy meeting the requirements of ASTM B 686, Alloy A 356 (A 13560) or equivalent. Flat cast surfaces exceeding 12 inches in both directions shall have a minimum thickness of 0.25 inches. Flat cast surfaces not exceeding 12 inches in both directions shall have a minimum thickness of 0.187 inches.
2. All DMS enclosures shall meet the requirements for TYPE 3R enclosures according to NEMA Standard Publication 250. All seams and openings shall be designed to prevent entry of water resulting from high pressure washing of the DMS enclosure.
3. Unpainted aluminum DMS enclosures shall be fabricated from mill-finish material and shall be cleaned using appropriate methods that will remove oil, film, weld black, and mill ink marks and render the surface clean, bright, smooth, and non-sticky to touch. Isolate all adjacent dissimilar materials, as approved by the Department.
4. All nuts and bolts used in the DMS assembly shall be stainless steel. All connecting surfaces shall be weatherproof and watertight when secured. All internal components shall be mounted so that there are no external protrusions.
5. The DMS shall be in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except as modified herein: The DMS enclosures shall be designed and constructed to present a clean, neat appearance and the equipment located inside shall be adequately protected from moisture, dust, dirt, corrosion, and excessive heat.

6. All surfaces shall be suitably protected from the weather. All corners and seams shall be heli-arc welded to provide a weatherproof seal around the entire case.
7. The DMS enclosure shall not be adversely affected by salt from the roadways or marine environments or chemicals or fumes discharged from nearby automobiles, industries and other sources. The interior of the DMS face window and the LEDs shall be easily accessible for cleaning and other maintenance.
8. Appropriate precautions, such as heating elements or ventilation fans or openings, shall be taken to ensure that condensation does not occur between the matrix elements and the DMS window face, and that the environment inside all enclosures remains within the temperature and humidity limits required for proper operation of the sign's electronic components.
9. Provide temperature sensor(s) in the DMS enclosure that is/are controlled and monitored by the DMS controller. Provide the capability for user defined critical thresholds to be established and changed remotely from the Department TMC or other location using the sign controller.
10. Provide humidity sensor(s) within the DMS enclosure that can detect relative humidity from 0%-100% in 1% or smaller increments. Provide an interface between the humidity sensor and the DMS controller which allows humidity levels to be monitored remotely from the TMC. Provide a sensor with an accuracy that exceeds 5% relative humidity.
11. All hinges used shall be continuous stainless steel, equipped with stainless steel hinge pins. Each hinge shall be secured with stainless steel bolts and lock nuts. The hinge pins and bolts shall be tamper proof.
12. The dead load shall consist of the total weight as installed of the DMS enclosure and appurtenances. The point of application of weights of the individual items shall be their representative centers of gravity.
13. Ice load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except that ice load shall be applied to all sides and top surfaces of the DMS enclosure simultaneously.
14. Wind load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals, except as modified herein: the enclosure and their mountings shall withstand a sustained wind speed of 90 miles per hour (mph), with a gust factor of 1.3.
15. Full 100 percent impact shall be used for handling and erection stress.

The DMS shall be capable of being mounted without gaining access to the inside of the enclosure. All mounting eyes shall be attached to the DMS enclosure structural framing.

Removal of any of the display modules or any other electronic or electrical component, shall not alter the structural integrity of the DMS display assembly or the DMS enclosure.

Access opening shall allow maintenance personnel immediate access to circuit boards and internal sign parts, without having to remove any item in the sign, or the need to use any tools or to remove any device that could be dropped or lost, such as a locking pin or bolt. Each opening shall be sealed to prevent the elements from entering, and shall have at least two locking points to keep unauthorized persons from accessing the interior of the DMS. In addition, each opening shall be provided with rigid,

telescopic, retention device, to keep the panel in the open position. All panels, when in the open position, shall not obstruct any portion of the opening. The opening system shall pull the panel tight and compress a gasket located around the perimeter. The gasket shall prevent water from entering the interior of the cabinet.

All serviceable components shall be modular, interchangeable and removable from within the DMS enclosure. The sign design shall allow unobstructed and convenient access to all serviceable components within the DMS enclosure and between the DMS display and the DMS display cover.

Drain holes shall be provided and designed to remove any condensation that may form inside the DMS enclosure and allow any water that may have collected in the housing to escape. All holes shall be screened to prevent small objects, insects and creatures from entering into the enclosure.

Heating, cooling and/or dehumidifying equipment shall be sized to maintain the internal DMS enclosure temperature within the operating ranges of the electric, electronic and mechanical equipment components. The environmental equipment shall have controls which shall shut down the DMS just prior to the temperature that the interior of the enclosure reaches the rated maximum operating temperature of the LEDs, and shall restore operation when the temperature has returned to safe operating levels. The shutdown shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

Electric ventilation fans shall be provided to generate positive pressure ventilation and shall be sized to provide 25 percent excess ventilation capacity, with one fan inoperative, over that required to maintain the DMS enclosure interior temperature within the range over which the DMS components can operate without failure or degradation, during full daylight heat gain conditions. All fans shall have ball or roller bearings. Fan operation and failure shall be reported to the DMS Central Processor via the communications protocol.

Louvered air inlets with removable, non-proprietary 500 micron, 2-stage filters and air deflector, sized to provide a maximum air intake velocity of 600 feet per minute with all fans operating. The direction of airflow and the filter characteristics (i.e., filter model number, type, dimensions, and particle size) shall be permanently engraved on each air vent. Exhaust air vents, if without filters, shall be screened to prevent small objects and creatures from entering into the enclosure.

A vent-free DMS housing for front access devices will be considered if satisfactory evidence of proper operation is supplied with the technical submittal, including factory or third-party certification. Vent-free design shall ensure that the DMS enclosure interior temperature does not exceed the maximum range of the DMS components to ensure continued operation without failure or degradation, particularly during full daylight heat gain.

13.3 LEDs

The LEDs that make up the display modules shall be high luminous intensity T-1 3/4" type manufactured by a reputable manufacturer. The LEDs shall have an ultraviolet light inhibitor in the epoxy dome package and be of a production type already tested for use in high vibration commercial traffic environments and climate of the mid-Atlantic United States.

Each DMS LED module shall be comprised of Amber LEDs that meet AlInGaP semiconductor technology that has a peak wavelength of 588-592nm.

All LEDs shall have a nominal viewing cone of 30 degrees with a half-power angle of 15 degrees measured from the longitudinal axis of the LED.

The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

The LEDs used in the display shall be obtained from batches sorted for luminous output, where the highest luminosity LED in the batch shall not be more than fifty percent more luminous than the lowest luminosity LED in the batch when operated at the manufacturer's recommended drive current. To ensure uniformity of display and operational life, all LEDs used to make up a display module shall be obtained from the same manufacturing batch.

The LED manufacturer shall perform intensity sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive luminous intensity "bins" as defined by the LED manufacturer.

The LED manufacturer shall perform color sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive color "bins" as defined by the LED manufacturer.

The LED mean time before failure (MTBF) shall be a minimum of 100,000 hours of elapsed time calendar hours use in an ambient temperature of 131 degrees Fahrenheit, based on an average daily on-time usage factor of 50%, when driven at the specific forward current recommended by the LED manufacturer for normal daylight DMS display operation. As part of the LED manufacturer's technical specification sheet submittal, the specific forward current shall be noted.

The statistical average long term light output degradation of the LEDs used in the display, operated at the LED manufacturer's recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure in an ambient temperature of 131 degrees Fahrenheit, shall not exceed the following:

1. A maximum of 10% reduction in light output after 10,000 hours of continuous on time.
2. A maximum of 25% reduction in light output after 50,000 hours of continuous on time.
3. A maximum of 30% reduction in light output after 100,000 hours of continuous on-time.
4. Manufacturer's documentation for high temperature operating life (HTOL) shall indicate if HTOL values are based upon actual or extrapolated data.

13.4 Display Modules

The LED display modules shall have a minimum refresh rate of 60 times per second to prevent visible flicker.

The LEDs shall be grouped in pixels consisting of discrete LEDs arranged in a continuous matrix display with individual pixel addressability. The centers of all pixels shall be arranged so as to maintain the same horizontal and vertical spacing between adjacent pixels. All pixels shall be replaceable. The LED grouping and mounting angle shall be optimized for maximum readability.

The electronics for the DMS shall be fully configured to drive the total required number of LEDs. The failure of any one pixel shall not affect the operation of any other pixel. The power driver circuitry shall be designed to minimize power consumption. Each LED display module shall have a diagnostic capability to detect a failure on the LED display module, down to the pixel level and report the failure to the DMS controller.

Removal of any display module shall not affect the operation of the remaining modules.

The LED modules shall be protected from degradation due to sunlight. The method used shall not obstruct the view of the display or reduce the viewing angle below that provided by an unprotected LED module. The method and design of the DMS sunlight protection shall be approved by the Department.

Each pixel shall contain an adequate number of discrete LEDs, based on a nominal pixel spacing of 1.30-1.35 inches, center to center, to meet the luminosity requirements herein.

Each discrete LED on the display module is driven at the LED manufacturer's recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure.

All DMS must be capable of meeting or exceeding the Manual of Uniform Traffic Control Devices (MUTCD) guidelines for inter-character and inter-line spacing of 25% and 50% of character height, respectively.

The 18" character of the Freeway DMS shall be clearly visible and legible from in-vehicle distance of 1,000 feet from the DMS face under clear daylight and nighttime conditions with the DMS face positioned in the roadway line of sight.

13.5 Dimming Circuitry

The DMS shall have a photocell controlled dimming circuit which shall automatically adjust the luminance of the LED display pixels in accordance with ambient light conditions. As part of the Proposer's submittal, a complete schematic of the LED display power, driver and dimming circuits shall be provided for approval by the Department.

Continuous current drive shall be used at the maximum brightness level. The current used for maximum brightness shall not exceed the current used to achieve the rated mean time before failure (MTBF). The current used for maximum brightness shall be indicated as part of the submittal.

For luminance levels less than maximum brightness, either continuous current drive or current pulse width modulation shall be used to dim the LEDs. If pulse width modulation is used, the dimming circuit shall be designed so that the maximum, instantaneous and average currents shall not exceed the rated peak and transient forward current ratings of the LEDs.

The DMS shall be equipped with a minimum of two external light sensors oriented in opposite directions and shall be scaled for up to 100,000 lux.

The LED dimming circuit shall also incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the LED current does not exceed the rated LED current at that temperature. If the temperature of the DMS

exceeds the rated operating temperature of the LEDs the DMS shall blank-out, until the temperature has returned to safe operating levels.

The LED dimming circuit shall not cause the LED display to flicker as the temperature oscillates above and below the rated operating temperature of the LEDs.

13.6 Power Supply

The DMS shall be operated at a low internal DC voltage not exceeding 24 Volts.

The quantity of power supplies and current rating of each power supply shall be at least 25% spare capacity over that required to light every pixel of the DMS at full brightness.

The DMS and controller shall have redundant power supplies wired so that in the event of a failure of any one power supply, the second power supply shall automatically power that portion of the sign. Power supply failure shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

The power supplies shall be short circuit protected and shall reset automatically after 5 seconds of AC power off. The power supplies shall be protected by a suitable overcurrent protection device.

The power supply shall have an efficiency rating of 85%, minimum.

The operating temperature range of the power supply inside the DMS enclosure shall be negative 20 degrees Fahrenheit to 140 degrees Fahrenheit.

The power supply shall be UL listed.

13.7 Controller

The DMS controller shall be a microprocessor-based unit with sufficient on-board memory and input and output interfaces to provide all the functions required by this Section.

The DMS controller shall accommodate both local and remote control from multiple host devices as described herein. Local control shall be supported from a locally connected sign programmer. Remote control shall be supported from a remotely located DMS Central Processor (control computer system).

The DMS controller shall receive and interpret commands sent by the host device to either configure the DMS or cause a requested message to be displayed on the DMS. Based on the command, the DMS Controller shall provide return data to the host device to provide information about the status of the sign.

The DMS controller shall be capable of simultaneously receiving commands from and transmitting status data to multiple host devices; i.e., the sign programmer, local control panel and the DMS Central Processor.

The method of control of the DMS shall be dependent upon the setting of the Control Mode Selector switch in each local control panel. This switch shall allow for two modes of operation:

"Remote" mode: This is the normal mode of operation of the DMS, where all control is from a remote DMS Central Processor, via NTCIP data exchanged directly between the remote DMS Central Processor and the DMS controller.

"Local" mode: When the Control Mode Selector switch is in this position, control from the remote DMS Central Processor shall be disabled and the DMS shall be controlled in accordance with commands entered via the message selector switch on the Local Control Panel or a NTCIP data exchanged directly with a locally connected Sign Programmer. When in "local" mode, the remote DMS Central Processor shall still be able to monitor the status of the DMS.

When switching from one mode to another, the DMS shall continue to display its current message, until it receives a command to display another message, from either the remote DMS Central Processor or the local controls, as applicable.

A change of position of the mode selector switch shall be immediately reported to the DMS Central Processor in the form of an alarm, and shall be logged internally at the site CPU for retrieval on the next polling cycle, and in accordance with the communications protocol.

Each DMS controller shall have error detection and reporting features which shall be utilized to guard against incomplete or incorrect information transmission, message generation and display on the DMS, as well as provide capability to detect a failure down to a replaceable component and report the failure and failed component. All errors and hardware failures shall be logged and reported to the DMS Central Processor or Sign Programmer (if connected) via the communications protocol. The DMS controller shall have the capability to automatically recover from failure conditions when the failure conditions are corrected or the failures are no longer present, and report the restored operation of the DMS to the DMS Central Processor or Sign Programmer (if connected).

The DMS controller shall have diagnostic capabilities features to:

1. Perform redundant checking of all data received and transmitted, and incorporate cyclic redundancy check (CRC) error detection logic, as specified by the NTCIP standards.
2. Validate the content of all received transmissions.
3. Check and report logic or data errors.
4. Monitor status for communication line malfunction or break.
5. Respond to system polling from the DMS Central Processor.
6. Check and report errors in display driver operation.
7. Check and report the failure and location of bad pixels.
8. Check and report the failure of bad fans.
9. Check and report whether the controller cabinet or DMS enclosure door is open or closed.
10. Check the operation and report the failure and location of bad power supplies.
11. Check the duration of power failures.
12. Check and report the number of occurrences the watchdog timer resets the controller.

Whenever any of the following error or failure conditions is detected, the DMS controller shall blank the DMS and shall include the error or failure in the return message:

1. The number of pixels that are not working for the particular sign type exceed a specified maximum value. The Proposer shall determine this number for each sign type and have these numbers approved by the Department.
2. The ratio of the number of pixels that achieve a commanded state divided by the number of pixels commanded to that state exceeds a legibility threshold value. The test shall include only those pixels that are contained in the character positions of the message text.
3. Communication loss greater than a configurable time value measured in minutes. The default value shall be 10 minutes. If a system poll is not received within a configurable threshold period, the controller shall blank all signs connected to it. The configuration of system polling shall also have an option for disabling this feature.
4. Upon detection of a power failure to the DMS controller or the DMS display(s) connected to the controller, the current message displayed on the DMS just prior to the power failure shall be retained in memory.
5. Upon power restoration, the DMS shall remain blank if the duration of the power failure exceeded the configurable long term power failure duration threshold, else the previous message shall be restored to its respective DMS. The default value of the long term power failure duration threshold shall be 10 minutes.
6. Overheating condition in DMS enclosure: The LED dimming circuit shall also incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the it does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs, the DMS shall blank-out until the temperature has returned to safe operating levels.
7. Information on each of the specific failures shall be sent to the DMS Central Processor.

Each DMS controller shall have the capability of displaying messages transmitted directly from a DMS Central Processor or Sign Programmer in addition to displaying locally commanded messages from a pre-programmed local message library. Each sign's local message library shall have the capacity to store a minimum of 256 display messages with related display attributes for each message, such as flashing rate and percent "on" time. The local message library shall consist of:

1. A "changeable, non-volatile" local message library stored in battery-backed RAM. The changeable local message library shall be programmable through both the DMS Central Processor and the Sign Programmer.
2. A "permanent, non-volatile" local message library, stored on EPROM shall be provided. Battery-backed RAM memory shall not be acceptable. If a microprocessor-based controller is used, then EEPROM, flash RAM or similar technology memory devices, programmed as described herein, may be used to store the message library.

Each DMS controller shall write messages on the DMS at a minimum rate of 300 characters per second.

Each DMS controller shall have an easily accessible and clearly labeled ON/OFF switch. When in the "OFF" position all power shall be disconnected from the DMS control electronics and matrix units and the DMS shall blank-out.

The Proposer shall provide a means of establishing a monetary reset switch on the DMS controller. The contact switch shall reset the DMS controller when depressed. Operation of the momentary contact switch shall not require the user to hold the switch in the depressed position for more than 0.25 seconds.

The DMS controller shall interface and communicate with one or more Operator Interfaces, as indicated on the Contract Drawings. Operator Interfaces and associated functions shall be as described elsewhere herein.

The DMS controller shall be provided with all software and hardware required to perform the following functions:

1. Password protection to restrict access to control and configuration functions.
2. Fully programmable parameters for all functions described in this section.
3. Real-time clock and calendar for timing and scheduling of automatic functions. The calendar shall automatically adjust itself for leap years, and for changeover from Standard to Daylight savings time and back.
4. Variable message flash rate and percent "on" time.
    a. Flash rate shall be adjustable in one-tenth second increments.
    b. Percent "on" time shall be adjustable from 0 to 9.9 seconds, in one-tenth second increments.
5. Multi-page messages with variable page display times that are adjustable in one-tenth second increments from 0 to 15.0 seconds.
6. Negative text inversion (or inverse/reverse video) - switch between illuminated text on a dark background or dark text on an illuminated background. Inverse/reverse video shall be implemented with the use of standard NTCIP foreground and background objects.
7. Configurable line justification (center, left or right) with center justification as the default setting.
8. Configurable page justification (top, center, bottom) with center justification as the default setting.
9. Configurable message duration parameter, to specify how long the current message should remain displayed regardless of the status of the communications with the DMS Central Processor.
10. Communications Loss message threshold, to specify how long the current message should remain displayed in the absence of communications with the DMS Central Processor.
11. Control of pixel luminance levels, both directly and based on ambient light levels obtained from the photocells. Luminance levels shall be stored in the DMS controller and shall be adjustable, in a range of 0 to 255, on either a continuous logarithmic basis, to match the normal human eye luminous response characteristic, or a 1/2 incremental dimming basis, where each lower dimming level is 1/2 the previous level.
12. Monitoring of each pixel of the DMS.
13. Monitoring of power failures: When a power failure is detected, the displayed message shall be retained in memory. If power to the DMS controller is restored within a configurable period of time, the last displayed message shall be restored. If the duration of the power failure exceeds the configured period of time, the DMS shall remain blank, until a command to

display a message is received. Upon restoration of power, the DMS controller shall report the occurrence, time and duration of the power failure, to the DMS Central Processor or Sign Programmer, if connected.

14. Hardware watchdog timer: The DMS controller shall have a hardware watchdog timer that shall check for a stall condition in the controller hardware, software or firmware. While the DMS controller is powered on, the software shall poll the watchdog timer. Upon reset, the watchdog timer shall initialize its timing circuit. If the watchdog timing circuit times out without being reset by the software, the watchdog counter shall be incremented and the watchdog shall reset the controller to clear a potential stall condition from the hardware, software or firmware and send an error message to the DMS Central Processor or Sign Programmer (if connected) to advise of the condition. The number of occurrences that the watchdog timer resets the controller shall be transmitted to the DMS Central Processor or Sign Programmer (if connected) upon request and then cleared.
15. Programmable Font Sets: The DMS controller shall support multiple programmable font sets. At a minimum, this should include fonts for 6", 9", 12", and 18" character heights, variable and fixed width fonts, and single, double, and triple stroke fonts. Each font set shall be capable of being programmed from the DMS Central Processor or the Sign Programmer if connected. Additional font sets may be provided at no additional cost and will be considered as additional value added to the proposal.
16. Each font set shall include, but not be limited to, all upper case letters, numerals, punctuation marks and arrows that are displayed in each of the eight cardinal directions.
17. Customizable and Standard Graphics Library: Provide a suite of pre-generated MUTCD style symbols, along with the ability to modify or create independent symbols, saving of new graphics and editing. The library should hold a minimum of 50 graphics.
18. The DMS controller shall keep a log of all system errors, malfunctions, automatic operations and locally controlled commands and activities. All logs shall be time and date stamped. The DMS controller shall have sufficient memory to store a minimum of 500 log entries. If 100% of the log storage memory has been reached without a successful download to the DMS Central Processor or a Sign Programmer, the oldest log entry shall be overwritten. The DMS controller shall download all log entries to a DMS Central Processor or Sign Programmer, upon user request from one of these devices and clear the log.

13.8 Controller Cabinet

All DMS controller cabinets will be furnished and installed by DelDOT's Traffic Signal/ITS Construction Contractor. Coordinate with DelDOT to confirm size, layout, power supply, and mounting/orientation of DMS controller cabinets prior to executing each individual purchase order.

13.9 Communications

Provide layout space for a cellular modem and antenna, Ethernet network switches, and/or 4.9GHz communications network equipment.

The DMS controller shall have a minimum of two (2) serial data and one (1) Ethernet communications ports to facilitate simultaneous communications for local and remote control, programming, and diagnostics.

When connected to a serial port, the DMS shall automatically use the NTCIP communications stack associated with serial communications, i.e., NTCIP 2101, NTCIP 2201, and NTCIP 2301.

When connected to the Ethernet port, the DMS shall automatically use the NTCIP communications stack associated with Ethernet communications, i.e., NTCIP 2104, NTCIP 2202, and NTCIP 2301. All ports shall be configurable such that:

3. Communications with the serial ports shall support all typical serial baud rates ranging from 1200 to 115,200 baud.
4. Communications with the Ethernet port shall be capable of communicating via TCP/IP or UDP/IP at 10 or 100 MB.

The serial ports in the DMS sign controller shall be protected with surge protection to protect the modem communication port from over-voltage and overcurrent conditions between each signal line and ground.

13.10 Software

Furnish NTCIP compatible control/diagnostic software for the purpose of troubleshooting and testing. The software shall send requests and receive responses over any TCP/IP-based network for the functions of controlling DMS messaging, monitoring system status and performing DMS diagnostics (detecting failed pixels, display drivers, power supplies, alarm conditions, etc.).

For the details and definitions for the actual NTCIP communications protocols used to accomplish this, Section 9.0.

14.0 DMS System Type 5 – Small Size, Front Access, Color

14.1 General

Design and furnish a Light Emitting Diode (LED) Dynamic Message Sign providing a full matrix color display for freeway traveler information applications. The DMS matrix shall be sized sufficient to provide display of three (3) rows of twelve (12) characters, with a nominal character size of 12-inches and a pixel pitch of between 0.79 to 0.81 inches. The sign shall provide front access to all interior components.

Provide a fully debugged DMS system complete with all individual units, components, software modules, cabling, connectors etc. that are completely compatible with each other and are capable of being controlled by the current ATMS being operated at the Department TMC.

14.2 Housing/Enclosure

Design and furnish a DMS enclosure of a design and shape as to house all necessary display modules, display driver electronics, transformers, power supplies and other internal sign equipment.

Provide a weatherproof housing and internal equipment rated to withstand a humidity range of 0-99% non-condensing.

Construct enclosure of a corrosion resistant aluminum material conforming to the following:

1. Sheet aluminum shall be fabricated from aluminum alloy sheet meeting the requirements of ASTM B 209, Alloy 5052, Temper H3, or equivalent, minimum 0.125 inch thick. Cast aluminum shall be fabricated from aluminum alloy meeting the requirements of ASTM B 686, Alloy A 356 (A 13560) or equivalent. Flat cast surfaces exceeding 12 inches in both directions shall have a minimum thickness of 0.25 inches. Flat cast surfaces not exceeding 12 inches in both directions shall have a minimum thickness of 0.187 inches.
2. All DMS enclosures shall meet the requirements for TYPE 3R enclosures according to NEMA Standard Publication 250. All seams and openings shall be designed to prevent entry of water resulting from high pressure washing of the DMS enclosure.
3. Unpainted aluminum DMS enclosures shall be fabricated from mill-finish material and shall be cleaned using appropriate methods that will remove oil, film, weld black, and mill ink marks and render the surface clean, bright, smooth, and non-sticky to touch. Isolate all adjacent dissimilar materials, as approved by the Department.
4. All nuts and bolts used in the DMS assembly shall be stainless steel. All connecting surfaces shall be weatherproof and watertight when secured. All internal components shall be mounted so that there are no external protrusions.
5. The DMS shall be in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except as modified herein: The DMS enclosures shall be designed and constructed to present a clean, neat appearance and the equipment located inside shall be adequately protected from moisture, dust, dirt, corrosion, and excessive heat.

6. All surfaces shall be suitably protected from the weather. All corners and seams shall be heli-arc welded to provide a weatherproof seal around the entire case.
7. The DMS enclosure shall not be adversely affected by salt from the roadways or marine environments or chemicals or fumes discharged from nearby automobiles, industries and other sources. The interior of the DMS face window and the LEDs shall be easily accessible for cleaning and other maintenance.
8. Appropriate precautions, such as heating elements or ventilation fans or openings, shall be taken to ensure that condensation does not occur between the matrix elements and the DMS window face, and that the environment inside all enclosures remains within the temperature and humidity limits required for proper operation of the sign's electronic components.
9. Provide temperature sensor(s) in the DMS enclosure that is/are controlled and monitored by the DMS controller. Provide the capability for user defined critical thresholds to be established and changed remotely from the Department TMC or other location using the sign controller.
10. Provide humidity sensor(s) within the DMS enclosure that can detect relative humidity from 0%-100% in 1% or smaller increments. Provide an interface between the humidity sensor and the DMS controller which allows humidity levels to be monitored remotely from the TMC. Provide a sensor with an accuracy that exceeds 5% relative humidity.
11. All hinges used shall be continuous stainless steel, equipped with stainless steel hinge pins. Each hinge shall be secured with stainless steel bolts and lock nuts. The hinge pins and bolts shall be tamper proof.
12. The dead load shall consist of the total weight as installed of the DMS enclosure and appurtenances. The point of application of weights of the individual items shall be their representative centers of gravity.
13. Ice load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except that ice load shall be applied to all sides and top surfaces of the DMS enclosure simultaneously.
14. Wind load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals, except as modified herein: the enclosure and their mountings shall withstand a sustained wind speed of 90 miles per hour (mph), with a gust factor of 1.3.
15. Full 100 percent impact shall be used for handling and erection stress.

The DMS shall be capable of being mounted without gaining access to the inside of the enclosure. All mounting eyes shall be attached to the DMS enclosure structural framing.

Removal of any of the display modules or any other electronic or electrical component, shall not alter the structural integrity of the DMS display assembly or the DMS enclosure.

Access opening shall allow maintenance personnel immediate access to circuit boards and internal sign parts, without having to remove any item in the sign, or the need to use any tools or to remove any device that could be dropped or lost, such as a locking pin or bolt. Each opening shall be sealed to prevent the elements from entering, and shall have at least two locking points to keep unauthorized persons from accessing the interior of the DMS. In addition, each opening shall be provided with rigid, telescopic, retention device, to keep the panel in the open position. All panels, when in the open

position, shall not obstruct any portion of the opening. The opening system shall pull the panel tight and compress a gasket located around the perimeter. The gasket shall prevent water from entering the interior of the cabinet.

All serviceable components shall be modular, interchangeable and removable from within the DMS enclosure. The sign design shall allow unobstructed and convenient access to all serviceable components within the DMS enclosure and between the DMS display and the DMS display cover.

Drain holes shall be provided and designed to remove any condensation that may form inside the DMS enclosure and allow any water that may have collected in the housing to escape. All holes shall be screened to prevent small objects, insects and creatures from entering into the enclosure.

Heating, cooling and/or dehumidifying equipment shall be sized to maintain the internal DMS enclosure temperature within the operating ranges of the electric, electronic and mechanical equipment components. The environmental equipment shall have controls which shall shut down the DMS just prior to the temperature that the interior of the enclosure reaches the rated maximum operating temperature of the LEDs, and shall restore operation when the temperature has returned to safe operating levels. The shutdown shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

Electric ventilation fans shall be provided to generate positive pressure ventilation and shall be sized to provide 25 percent excess ventilation capacity, with one fan inoperative, over that required to maintain the DMS enclosure interior temperature within the range over which the DMS components can operate without failure or degradation, during full daylight heat gain conditions. All fans shall have ball or roller bearings. Fan operation and failure shall be reported to the DMS Central Processor via the communications protocol.

Louvered air inlets with removable, non-proprietary 500 micron, 2-stage filters and air deflector, sized to provide a maximum air intake velocity of 600 feet per minute with all fans operating. The direction of airflow and the filter characteristics (i.e., filter model number, type, dimensions, and particle size) shall be permanently engraved on each air vent. Exhaust air vents, if without filters, shall be screened to prevent small objects and creatures from entering into the enclosure.

A vent-free DMS housing for front access devices will be considered if satisfactory evidence of proper operation is supplied with the technical submittal, including factory or third-party certification. Vent-free design shall ensure that the DMS enclosure interior temperature does not exceed the maximum range of the DMS components to ensure continued operation without failure or degradation, particularly during full daylight heat gain.

14.3 LEDs

The LEDs that make up the display modules shall be high luminous intensity T-1 3/4" type manufactured by a reputable manufacturer. The LEDs shall have an ultraviolet light inhibitor in the epoxy dome package and be of a production type already tested for use in high vibration commercial traffic environments and climate of the northeastern United States.

Each Full-color DMS LED module shall be comprised of Red Green and Blue LEDs that meet the following specifications:

1. Red LEDs shall utilize AlInGaP semiconductor technology and shall emit red light that has a peak wavelength of 615-635nm.
2. Green LEDs shall utilize InGaN semiconductor technology and shall emit green light that has a peak wavelength of 520-535nm.
3. Blue LEDs shall utilize InGaN semiconductor technology and shall emit blue light that has a peak wavelength of 464-475nm.

All LEDs shall have a nominal viewing cone of 30 degrees with a half-power angle of 15 degrees measured from the longitudinal axis of the LED.

The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

The LEDs used in the display shall be obtained from batches sorted for luminous output, where the highest luminosity LED in the batch shall not be more than fifty percent more luminous than the lowest luminosity LED in the batch when operated at the manufacturer's recommended drive current. To ensure uniformity of display and operational life, all LEDs used to make up a display module shall be obtained from the same manufacturing batch.

The LED manufacturer shall perform intensity sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive luminous intensity "bins" as defined by the LED manufacturer.

The LED manufacturer shall perform color sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive color "bins" as defined by the LED manufacturer.

The LED mean time before failure (MTBF) shall be a minimum of 100,000 hours of elapsed time calendar hours use in an ambient temperature of 131 degrees Fahrenheit, based on an average daily on-time usage factor of 50%, when driven at the specific forward current recommended by the LED manufacturer for normal daylight DMS display operation. As part of the LED manufacturer's technical specification sheet submittal, the specific forward current shall be noted.

The statistical average long term light output degradation of the LEDs used in the display, operated at the LED manufacturer's recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure in an ambient temperature of 131 degrees Fahrenheit, shall not exceed the following:

1. A maximum of 10% reduction in light output after 10,000 hours of continuous on time.
2. A maximum of 25% reduction in light output after 50,000 hours of continuous on time.
3. A maximum of 30% reduction in light output after 100,000 hours of continuous on-time.
4. Manufacturer's documentation for high temperature operating life (HTOL) shall indicate if HTOL values are based upon actual or extrapolated data.

14.4 Display Modules

The LED display modules shall have a minimum refresh rate of 60 times per second to prevent visible flicker.

The LEDs shall be grouped in pixels consisting of discrete LEDs arranged in a continuous matrix display with individual pixel addressability. The centers of all pixels shall be arranged so as to maintain the same horizontal and vertical spacing between adjacent pixels. All pixels shall be replaceable. The LED grouping and mounting angle shall be optimized for maximum readability.

The electronics for the DMS shall be fully configured to drive the total required number of LEDs. The failure of any one pixel shall not affect the operation of any other pixel. The power driver circuitry shall be designed to minimize power consumption. Each LED display module shall have a diagnostic capability to detect a failure on the LED display module, down to the pixel level and report the failure to the DMS controller.

Removal of any display module shall not affect the operation of the remaining modules.

The LED modules shall be protected from degradation due to sunlight. The method used shall not obstruct the view of the display or reduce the viewing angle below that provided by an unprotected LED module. The method and design of the DMS sunlight protection shall be approved by the Department.

Each pixel shall contain an adequate number of discrete LEDs, based on a nominal pixel spacing of 0.79 to 0.81 inches, center to center, to meet the luminosity requirements herein.

Each discrete LED on the display module is driven at the LED manufacturer’s recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure.

All DMS must be capable of meeting or exceeding the Manual of Uniform Traffic Control Devices (MUTCD) guidelines for inter-character and inter-line spacing of 25% and 50% of character height, respectively.

14.5 Dimming Circuitry

The DMS shall have a photocell controlled dimming circuit which shall automatically adjust the luminance of the LED display pixels in accordance with ambient light conditions. As part of the Proposer's submittal, a complete schematic of the LED display power, driver and dimming circuits shall be provided for approval by the Department.

Continuous current drive shall be used at the maximum brightness level. The current used for maximum brightness shall not exceed the current used to achieve the rated mean time before failure (MTBF). The current used for maximum brightness shall be indicated as part of the submittal.

For luminance levels less than maximum brightness, either continuous current drive or current pulse width modulation shall be used to dim the LEDs. If pulse width modulation is used, the dimming circuit shall be designed so that the maximum, instantaneous and average currents shall not exceed the rated peak and transient forward current ratings of the LEDs.

The DMS shall be equipped with a minimum of two external light sensors oriented in opposite directions and shall be scaled for up to 100,000 lux.

The LED dimming circuit shall also incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the LED current does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs the DMS shall blank-out, until the temperature has returned to safe operating levels.

The LED dimming circuit shall not cause the LED display to flicker as the temperature oscillates above and below the rated operating temperature of the LEDs.

14.6 Power Supply

The DMS shall be operated at a low internal DC voltage not exceeding 24 Volts.

The quantity of power supplies and current rating of each power supply shall be at least 25% spare capacity over that required to light every pixel of the DMS at full brightness.

The DMS and controller shall have redundant power supplies wired so that in the event of a failure of any one power supply, the second power supply shall automatically power that portion of the sign. Power supply failure shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

The power supplies shall be short circuit protected and shall reset automatically after 5 seconds of AC power off. The power supplies shall be protected by a suitable overcurrent protection device.

The power supply shall have an efficiency rating of 85%, minimum.

The operating temperature range of the power supply inside the DMS enclosure shall be negative 20 degrees Fahrenheit to 140 degrees Fahrenheit.

The power supply shall be UL listed.

14.7 Controller

The DMS controller shall be a microprocessor-based unit with sufficient on-board memory and input and output interfaces to provide all the functions required by this Section.

The DMS controller shall accommodate both local and remote control from multiple host devices as described herein. Local control shall be supported from a locally connected sign programmer. Remote control shall be supported from a remotely located DMS Central Processor (control computer system).

The DMS controller shall receive and interpret commands sent by the host device to either configure the DMS or cause a requested message to be displayed on the DMS. Based on the command, the DMS Controller shall provide return data to the host device to provide information about the status of the sign.

The DMS controller shall be capable of simultaneously receiving commands from and transmitting status data to multiple host devices; i.e., the sign programmer, local control panel and the DMS Central Processor.

The method of control of the DMS shall be dependent upon the setting of the Control Mode Selector switch in each local control panel. This switch shall allow for two modes of operation:

"Remote" mode: This is the normal mode of operation of the DMS, where all control is from a remote DMS Central Processor, via NTCIP data exchanged directly between the remote DMS Central Processor and the DMS controller.

"Local" mode: When the Control Mode Selector switch is in this position, control from the remote DMS Central Processor shall be disabled and the DMS shall be controlled in accordance with commands entered via the message selector switch on the Local Control Panel or a NTCIP data exchanged directly with a locally connected Sign Programmer. When in "local" mode, the remote DMS Central Processor shall still be able to monitor the status of the DMS.

When switching from one mode to another, the DMS shall continue to display its current message, until it receives a command to display another message, from either the remote DMS Central Processor or the local controls, as applicable.

A change of position of the mode selector switch shall be immediately reported to the DMS Central Processor in the form of an alarm, and shall be logged internally at the site CPU for retrieval on the next polling cycle, and in accordance with the communications protocol.

Each DMS controller shall have error detection and reporting features which shall be utilized to guard against incomplete or incorrect information transmission, message generation and display on the DMS, as well as provide capability to detect a failure down to a replaceable component and report the failure and failed component. All errors and hardware failures shall be logged and reported to the DMS Central Processor or Sign Programmer (if connected) via the communications protocol. The DMS controller shall have the capability to automatically recover from failure conditions when the failure conditions are corrected or the failures are no longer present, and report the restored operation of the DMS to the DMS Central Processor or Sign Programmer (if connected).

The DMS controller shall have diagnostic capabilities features to:

1. Perform redundant checking of all data received and transmitted, and incorporate cyclic redundancy check (CRC) error detection logic, as specified by the NTCIP standards.
2. Validate the content of all received transmissions.
3. Check and report logic or data errors.
4. Monitor status for communication line malfunction or break.
5. Respond to system polling from the DMS Central Processor.
6. Check and report errors in display driver operation.
7. Check and report the failure and location of bad pixels.
8. Check and report the failure of bad fans.
9. Check and report whether the controller cabinet or DMS enclosure door is open or closed.
10. Check the operation and report the failure and location of bad power supplies.

11. Check the duration of power failures.
12. Check and report the number of occurrences the watchdog timer resets the controller.

Whenever any of the following error or failure conditions is detected, the DMS controller shall blank the DMS and shall include the error or failure in the return message:

1. The number of pixels that are not working for the particular sign type exceed a specified maximum value. The Proposer shall determine this number for each sign type and have these numbers approved by the Department.
2. The ratio of the number of pixels that achieve a commanded state divided by the number of pixels commanded to that state exceeds a legibility threshold value. The test shall include only those pixels that are contained in the character positions of the message text.
3. Communication loss greater than a configurable time value measured in minutes. The default value shall be 10 minutes. If a system poll is not received within a configurable threshold period, the controller shall blank all signs connected to it. The configuration of system polling shall also have an option for disabling this feature.
4. Upon detection of a power failure to the DMS controller or the DMS display(s) connected to the controller, the current message displayed on the DMS just prior to the power failure shall be retained in memory.
5. Upon power restoration, the DMS shall remain blank if the duration of the power failure exceeded the configurable long term power failure duration threshold, else the previous message shall be restored to its respective DMS. The default value of the long term power failure duration threshold shall be 10 minutes.
6. Overheating condition in DMS enclosure: The LED dimming circuit shall also incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the it does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs, the DMS shall blank-out until the temperature has returned to safe operating levels.
7. Information on each of the specific failures shall be sent to the DMS Central Processor.

Each DMS controller shall have the capability of displaying messages transmitted directly from a DMS Central Processor or Sign Programmer in addition to displaying locally commanded messages from a pre-programmed local message library. Each sign's local message library shall have the capacity to store a minimum of 256 display messages with related display attributes for each message, such as flashing rate and percent "on" time. The local message library shall consist of:

1. A "changeable, non-volatile" local message library stored in battery-backed RAM. The changeable local message library shall be programmable through both the DMS Central Processor and the Sign Programmer.
2. A "permanent, non-volatile" local message library, stored on EPROM shall be provided. Battery-backed RAM memory shall not be acceptable. If a microprocessor-based controller is used, then EEPROM, flash RAM or similar technology memory devices, programmed as described herein, may be used to store the message library.

Each DMS controller shall write messages on the DMS at a minimum rate of 300 characters per second.

Each DMS controller shall have an easily accessible and clearly labeled ON/OFF switch. When in the "OFF" position all power shall be disconnected from the DMS control electronics and matrix units and the DMS shall blank-out.

The Proposer shall provide a means of establishing a monetary reset switch on the DMS controller. The contact switch shall reset the DMS controller when depressed. Operation of the momentary contact switch shall not require the user to hold the switch in the depressed position for more than 0.25 seconds.

The DMS controller shall interface and communicate with one or more Operator Interfaces, as indicated on the Contract Drawings. Operator Interfaces and associated functions shall be as described elsewhere herein.

The DMS controller shall be provided with all software and hardware required to perform the following functions:

1. Password protection to restrict access to control and configuration functions.
2. Fully programmable parameters for all functions described in this section.
3. Real-time clock and calendar for timing and scheduling of automatic functions. The calendar shall automatically adjust itself for leap years, and for changeover from Standard to Daylight savings time and back.
4. Variable message flash rate and percent "on" time.
    a. Flash rate shall be adjustable in one-tenth second increments.
    b. Percent "on" time shall be adjustable from 0 to 9.9 seconds, in one-tenth second increments.
5. Multi-page messages with variable page display times that are adjustable in one-tenth second increments from 0 to 15.0 seconds.
6. Negative text inversion (or inverse/reverse video) - switch between illuminated text on a dark background or dark text on an illuminated background. Inverse/reverse video shall be implemented with the use of standard NTCIP foreground and background objects.
7. Configurable line justification (center, left or right) with center justification as the default setting.
8. Configurable page justification (top, center, bottom) with center justification as the default setting.
9. Configurable message duration parameter, to specify how long the current message should remain displayed regardless of the status of the communications with the DMS Central Processor.
10. Communications Loss message threshold, to specify how long the current message should remain displayed in the absence of communications with the DMS Central Processor.
11. Control of pixel luminance levels, both directly and based on ambient light levels obtained from the photocells. Luminance levels shall be stored in the DMS controller and shall be adjustable, in a range of 0 to 255, on either a continuous logarithmic basis, to match the normal human eye luminous response characteristic, or a 1/2 incremental dimming basis, where each lower dimming level is 1/2 the previous level.
12. Monitoring of each pixel of the DMS.

13. Monitoring of power failures: When a power failure is detected, the displayed message shall be retained in memory. If power to the DMS controller is restored within a configurable period of time, the last displayed message shall be restored. If the duration of the power failure exceeds the configured period of time, the DMS shall remain blank, until a command to display a message is received. Upon restoration of power, the DMS controller shall report the occurrence, time and duration of the power failure, to the DMS Central Processor or Sign Programmer, if connected.
14. Hardware watchdog timer: The DMS controller shall have a hardware watchdog timer that shall check for a stall condition in the controller hardware, software or firmware. While the DMS controller is powered on, the software shall poll the watchdog timer. Upon reset, the watchdog timer shall initialize its timing circuit. If the watchdog timing circuit times out without being reset by the software, the watchdog counter shall be incremented and the watchdog shall reset the controller to clear a potential stall condition from the hardware, software or firmware and send an error message to the DMS Central Processor or Sign Programmer (if connected) to advise of the condition. The number of occurrences that the watchdog timer resets the controller shall be transmitted to the DMS Central Processor or Sign Programmer (if connected) upon request and then cleared.
15. Programmable Font Sets: The DMS controller shall support multiple programmable font sets. At a minimum, this should include fonts for 6", 9", 12", and 18" character heights, variable and fixed width fonts, and single, double, and triple stroke fonts. Each font set shall be capable of being programmed from the DMS Central Processor or the Sign Programmer if connected. Three of the font sets shall look like the E-modified font set defined by the MUTCD, replicating the appearance of the font used on some static signage on the DMS. A single, double and triple stroke E-modified font shall be provided. Additional font sets may be provided at no additional cost and will be considered as additional value added to the proposal.
16. Each font set shall include, but not be limited to, all upper case letters, numerals, punctuation marks and arrows that are displayed in each of the eight cardinal directions.
17. Customizable and Standard Graphics Library: Provide a suite of pre-generated MUTCD style symbols, along with the ability to modify or create independent symbols, saving of new graphics and color editing. The library should hold a minimum of 50 graphics.
18. The DMS controller shall keep a log of all system errors, malfunctions, automatic operations and locally controlled commands and activities. All logs shall be time and date stamped. The DMS controller shall have sufficient memory to store a minimum of 500 log entries. If 100% of the log storage memory has been reached without a successful download to the DMS Central Processor or a Sign Programmer, the oldest log entry shall be overwritten. The DMS controller shall download all log entries to a DMS Central Processor or Sign Programmer, upon user request from one of these devices and clear the log.
19. The DMS and Controller shall be capable of displaying a minimum of 256 different colors. DMS Controller shall be capable of displaying colors that conform to MUTCD requirements.

14.8 Controller Cabinet

All DMS controller cabinets will be furnished and installed by DelDOT's Traffic Signal/ITS Construction Contractor. Coordinate with DelDOT to confirm size, layout, power supply, and mounting/orientation of DMS controller cabinets prior to executing each individual purchase order.

14.9 Communications

Provide layout space for a cellular modem and antenna, Ethernet network switches, and/or 4.9GHz communications network equipment.

The DMS controller shall have a minimum of two (2) serial data and one (1) Ethernet communications ports to facilitate simultaneous communications for local and remote control, programming, and diagnostics.

When connected to a serial port, the DMS shall automatically use the NTCIP communications stack associated with serial communications, i.e., NTCIP 2101, NTCIP 2201, and NTCIP 2301.

When connected to the Ethernet port, the DMS shall automatically use the NTCIP communications stack associated with Ethernet communications, i.e., NTCIP 2104, NTCIP 2202, and NTCIP 2301. All ports shall be configurable such that:

1. Communications with the serial ports shall support all typical serial baud rates ranging from 1200 to 115,200 baud.
2. Communications with the Ethernet port shall be capable of communicating via TCP/IP or UDP/IP at 10 or 100 MB.

The serial ports in the DMS sign controller shall be protected with surge protection to protect the modem communication port from over-voltage and overcurrent conditions between each signal line and ground.

14.10 Software

Furnish NTCIP compatible control/diagnostic software for the purpose of troubleshooting and testing. The software shall send requests and receive responses over any TCP/IP-based network for the functions of controlling DMS messaging, monitoring system status and performing DMS diagnostics (detecting failed pixels, display drivers, power supplies, alarm conditions, etc.).

For the details and definitions for the actual NTCIP communications protocols used to accomplish this, Section 9.0.

15.0 DMS System Type 6 – Small Size, Front Access, Amber

15.1 General

Design and furnish a Light Emitting Diode (LED) Dynamic Message Sign providing a full matrix amber display for freeway traveler information applications. The DMS matrix shall be sized sufficient to provide display of three (3) rows of twelve (12) characters, with a nominal character size of 12-inches and a pixel pitch of between 1.30 to 1.35 inches. The sign shall provide front access to all interior components.

Provide a fully debugged DMS system complete with all individual units, components, software modules, cabling, connectors etc. that are completely compatible with each other and are capable of being controlled by the current ATMS being operated at the Department TMC.

15.2 Housing/Enclosure

Design and furnish a DMS enclosure of a design and shape as to house all necessary display modules, display driver electronics, transformers, power supplies and other internal sign equipment.

Provide a weatherproof housing and internal equipment rated to withstand a humidity range of 0-99% non-condensing.

Construct enclosure of a corrosion resistant aluminum material conforming to the following:

1. Sheet aluminum shall be fabricated from aluminum alloy sheet meeting the requirements of ASTM B 209, Alloy 5052, Temper H3, or equivalent, minimum 0.125 inch thick. Cast aluminum shall be fabricated from aluminum alloy meeting the requirements of ASTM B 686, Alloy A 356 (A 13560) or equivalent. Flat cast surfaces exceeding 12 inches in both directions shall have a minimum thickness of 0.25 inches. Flat cast surfaces not exceeding 12 inches in both directions shall have a minimum thickness of 0.187 inches.
2. All DMS enclosures shall meet the requirements for TYPE 3R enclosures according to NEMA Standard Publication 250. All seams and openings shall be designed to prevent entry of water resulting from high pressure washing of the DMS enclosure.
3. Unpainted aluminum DMS enclosures shall be fabricated from mill-finish material and shall be cleaned using appropriate methods that will remove oil, film, weld black, and mill ink marks and render the surface clean, bright, smooth, and non-sticky to touch. Isolate all adjacent dissimilar materials, as approved by the Department.
4. All nuts and bolts used in the DMS assembly shall be stainless steel. All connecting surfaces shall be weatherproof and watertight when secured. All internal components shall be mounted so that there are no external protrusions.
5. The DMS shall be in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except as modified herein: The DMS enclosures shall be designed and constructed to present a clean, neat appearance and the equipment located inside shall be adequately protected from moisture, dust, dirt, corrosion, and excessive heat.

6. All surfaces shall be suitably protected from the weather. All corners and seams shall be heli-arc welded to provide a weatherproof seal around the entire case.
7. The DMS enclosure shall not be adversely affected by salt from the roadways or marine environments or chemicals or fumes discharged from nearby automobiles, industries and other sources. The interior of the DMS face window and the LEDs shall be easily accessible for cleaning and other maintenance.
8. Appropriate precautions, such as heating elements or ventilation fans or openings, shall be taken to ensure that condensation does not occur between the matrix elements and the DMS window face, and that the environment inside all enclosures remains within the temperature and humidity limits required for proper operation of the sign's electronic components.
9. Provide temperature sensor(s) in the DMS enclosure that is/are controlled and monitored by the DMS controller. Provide the capability for user defined critical thresholds to be established and changed remotely from the Department TMC or other location using the sign controller.
10. Provide humidity sensor(s) within the DMS enclosure that can detect relative humidity from 0%-100% in 1% or smaller increments. Provide an interface between the humidity sensor and the DMS controller which allows humidity levels to be monitored remotely from the TMC. Provide a sensor with an accuracy that exceeds 5% relative humidity.
11. All hinges used shall be continuous stainless steel, equipped with stainless steel hinge pins. Each hinge shall be secured with stainless steel bolts and lock nuts. The hinge pins and bolts shall be tamper proof.
12. The dead load shall consist of the total weight as installed of the DMS enclosure and appurtenances. The point of application of weights of the individual items shall be their representative centers of gravity.
13. Ice load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except that ice load shall be applied to all sides and top surfaces of the DMS enclosure simultaneously.
14. Wind load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals, except as modified herein: the enclosure and their mountings shall withstand a sustained wind speed of 90 miles per hour (mph), with a gust factor of 1.3.
15. Full 100 percent impact shall be used for handling and erection stress.

The DMS shall be capable of being mounted without gaining access to the inside of the enclosure. All mounting eyes shall be attached to the DMS enclosure structural framing.

Removal of any of the display modules or any other electronic or electrical component, shall not alter the structural integrity of the DMS display assembly or the DMS enclosure.

Access opening shall allow maintenance personnel immediate access to circuit boards and internal sign parts, without having to remove any item in the sign, or the need to use any tools or to remove any device that could be dropped or lost, such as a locking pin or bolt. Each opening shall be sealed to prevent the elements from entering, and shall have at least two locking points to keep unauthorized persons from accessing the interior of the DMS. In addition, each opening shall be provided with rigid, telescopic, retention device, to keep the panel in the open position. All panels, when in the open

position, shall not obstruct any portion of the opening. The opening system shall pull the panel tight and compress a gasket located around the perimeter. The gasket shall prevent water from entering the interior of the cabinet.

All serviceable components shall be modular, interchangeable and removable from within the DMS enclosure. The sign design shall allow unobstructed and convenient access to all serviceable components within the DMS enclosure and between the DMS display and the DMS display cover.

Drain holes shall be provided and designed to remove any condensation that may form inside the DMS enclosure and allow any water that may have collected in the housing to escape. All holes shall be screened to prevent small objects, insects and creatures from entering into the enclosure.

Heating, cooling and/or dehumidifying equipment shall be sized to maintain the internal DMS enclosure temperature within the operating ranges of the electric, electronic and mechanical equipment components. The environmental equipment shall have controls which shall shut down the DMS just prior to the temperature that the interior of the enclosure reaches the rated maximum operating temperature of the LEDs, and shall restore operation when the temperature has returned to safe operating levels. The shutdown shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

Electric ventilation fans shall be provided to generate positive pressure ventilation and shall be sized to provide 25 percent excess ventilation capacity, with one fan inoperative, over that required to maintain the DMS enclosure interior temperature within the range over which the DMS components can operate without failure or degradation, during full daylight heat gain conditions. All fans shall have ball or roller bearings. Fan operation and failure shall be reported to the DMS Central Processor via the communications protocol.

Louvered air inlets with removable, non-proprietary 500 micron, 2-stage filters and air deflector, sized to provide a maximum air intake velocity of 600 feet per minute with all fans operating. The direction of airflow and the filter characteristics (i.e., filter model number, type, dimensions, and particle size) shall be permanently engraved on each air vent. Exhaust air vents, if without filters, shall be screened to prevent small objects and creatures from entering into the enclosure.

A vent-free DMS housing for front access devices will be considered if satisfactory evidence of proper operation is supplied with the technical submittal, including factory or third-party certification. Vent-free design shall ensure that the DMS enclosure interior temperature does not exceed the maximum range of the DMS components to ensure continued operation without failure or degradation, particularly during full daylight heat gain.

15.3 LEDs

The LEDs that make up the display modules shall be high luminous intensity T-1 3/4" type manufactured by a reputable manufacturer. The LEDs shall have an ultraviolet light inhibitor in the epoxy dome package and be of a production type already tested for use in high vibration commercial traffic environments and climate of the mid-Atlantic United States.

Each DMS LED module shall be comprised of Amber LEDs that meet AlInGaP semiconductor technology that has a peak wavelength of 588-592nm.

All LEDs shall have a nominal viewing cone of 30 degrees with a half-power angle of 15 degrees measured from the longitudinal axis of the LED.

The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

The LEDs used in the display shall be obtained from batches sorted for luminous output, where the highest luminosity LED in the batch shall not be more than fifty percent more luminous than the lowest luminosity LED in the batch when operated at the manufacturer's recommended drive current. To ensure uniformity of display and operational life, all LEDs used to make up a display module shall be obtained from the same manufacturing batch.

The LED manufacturer shall perform intensity sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive luminous intensity "bins" as defined by the LED manufacturer.

The LED manufacturer shall perform color sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive color "bins" as defined by the LED manufacturer.

The LED mean time before failure (MTBF) shall be a minimum of 100,000 hours of elapsed time calendar hours use in an ambient temperature of 131 degrees Fahrenheit, based on an average daily on-time usage factor of 50%, when driven at the specific forward current recommended by the LED manufacturer for normal daylight DMS display operation. As part of the LED manufacturer's technical specification sheet submittal, the specific forward current shall be noted.

The statistical average long term light output degradation of the LEDs used in the display, operated at the LED manufacturer's recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure in an ambient temperature of 131 degrees Fahrenheit, shall not exceed the following:

1. A maximum of 10% reduction in light output after 10,000 hours of continuous on time.
2. A maximum of 25% reduction in light output after 50,000 hours of continuous on time.
3. A maximum of 30% reduction in light output after 100,000 hours of continuous on-time.
4. Manufacturer's documentation for high temperature operating life (HTOL) shall indicate if HTOL values are based upon actual or extrapolated data.

15.4 Display Modules

The LED display modules shall have a minimum refresh rate of 60 times per second to prevent visible flicker.

The LEDs shall be grouped in pixels consisting of discrete LEDs arranged in a continuous matrix display with individual pixel addressability. The centers of all pixels shall be arranged so as to maintain the same horizontal and vertical spacing between adjacent pixels. All pixels shall be replaceable. The LED grouping and mounting angle shall be optimized for maximum readability.

The electronics for the DMS shall be fully configured to drive the total required number of LEDs. The failure of any one pixel shall not affect the operation of any other pixel. The power driver circuitry shall be designed to minimize power consumption. Each LED display module shall have a diagnostic capability to detect a failure on the LED display module, down to the pixel level and report the failure to the DMS controller.

Removal of any display module shall not affect the operation of the remaining modules.

The LED modules shall be protected from degradation due to sunlight. The method used shall not obstruct the view of the display or reduce the viewing angle below that provided by an unprotected LED module. The method and design of the DMS sunlight protection shall be approved by the Department.

Each pixel shall contain an adequate number of discrete LEDs, based on a nominal pixel spacing of 1.30-1.35 inches, center to center, to meet the luminosity requirements herein.

Each discrete LED on the display module is driven at the LED manufacturer's recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure.

All DMS must be capable of meeting or exceeding the Manual of Uniform Traffic Control Devices (MUTCD) guidelines for inter-character and inter-line spacing of 25% and 50% of character height, respectively.

15.5 Dimming Circuitry

The DMS shall have a photocell controlled dimming circuit which shall automatically adjust the luminance of the LED display pixels in accordance with ambient light conditions. As part of the Proposer's submittal, a complete schematic of the LED display power, driver and dimming circuits shall be provided for approval by the Department.

Continuous current drive shall be used at the maximum brightness level. The current used for maximum brightness shall not exceed the current used to achieve the rated mean time before failure (MTBF). The current used for maximum brightness shall be indicated as part of the submittal.

For luminance levels less than maximum brightness, either continuous current drive or current pulse width modulation shall be used to dim the LEDs. If pulse width modulation is used, the dimming circuit shall be designed so that the maximum, instantaneous and average currents shall not exceed the rated peak and transient forward current ratings of the LEDs.

The DMS shall be equipped with a minimum of two external light sensors oriented in opposite directions and shall be scaled for up to 100,000 lux.

The LED dimming circuit shall also incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the LED current does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs the DMS shall blank-out, until the temperature has returned to safe operating levels.

The LED dimming circuit shall not cause the LED display to flicker as the temperature oscillates above and below the rated operating temperature of the LEDs.

15.6 Power Supply

The DMS shall be operated at a low internal DC voltage not exceeding 24 Volts.

The quantity of power supplies and current rating of each power supply shall be at least 25% spare capacity over that required to light every pixel of the DMS at full brightness.

The DMS and controller shall have redundant power supplies wired so that in the event of a failure of any one power supply, the second power supply shall automatically power that portion of the sign. Power supply failure shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

The power supplies shall be short circuit protected and shall reset automatically after 5 seconds of AC power off. The power supplies shall be protected by a suitable overcurrent protection device.

The power supply shall have an efficiency rating of 85%, minimum.

The operating temperature range of the power supply inside the DMS enclosure shall be negative 20 degrees Fahrenheit to 140 degrees Fahrenheit.

The power supply shall be UL listed.

15.7 Controller

The DMS controller shall be a microprocessor-based unit with sufficient on-board memory and input and output interfaces to provide all the functions required by this Section.

The DMS controller shall accommodate both local and remote control from multiple host devices as described herein. Local control shall be supported from a locally connected sign programmer. Remote control shall be supported from a remotely located DMS Central Processor (control computer system).

The DMS controller shall receive and interpret commands sent by the host device to either configure the DMS or cause a requested message to be displayed on the DMS. Based on the command, the DMS Controller shall provide return data to the host device to provide information about the status of the sign.

The DMS controller shall be capable of simultaneously receiving commands from and transmitting status data to multiple host devices; i.e., the sign programmer, local control panel and the DMS Central Processor.

The method of control of the DMS shall be dependent upon the setting of the Control Mode Selector switch in each local control panel. This switch shall allow for two modes of operation:

"Remote" mode: This is the normal mode of operation of the DMS, where all control is from a remote DMS Central Processor, via NTCIP data exchanged directly between the remote DMS Central Processor and the DMS controller.

"Local" mode: When the Control Mode Selector switch is in this position, control from the remote DMS Central Processor shall be disabled and the DMS shall be controlled in accordance with commands entered via the message selector switch on the Local Control Panel or a NTCIP data exchanged directly with a locally connected Sign Programmer. When in "local" mode, the remote DMS Central Processor shall still be able to monitor the status of the DMS.

When switching from one mode to another, the DMS shall continue to display its current message, until it receives a command to display another message, from either the remote DMS Central Processor or the local controls, as applicable.

A change of position of the mode selector switch shall be immediately reported to the DMS Central Processor in the form of an alarm, and shall be logged internally at the site CPU for retrieval on the next polling cycle, and in accordance with the communications protocol.

Each DMS controller shall have error detection and reporting features which shall be utilized to guard against incomplete or incorrect information transmission, message generation and display on the DMS, as well as provide capability to detect a failure down to a replaceable component and report the failure and failed component. All errors and hardware failures shall be logged and reported to the DMS Central Processor or Sign Programmer (if connected) via the communications protocol. The DMS controller shall have the capability to automatically recover from failure conditions when the failure conditions are corrected or the failures are no longer present, and report the restored operation of the DMS to the DMS Central Processor or Sign Programmer (if connected).

The DMS controller shall have diagnostic capabilities features to:

1. Perform redundant checking of all data received and transmitted, and incorporate cyclic redundancy check (CRC) error detection logic, as specified by the NTCIP standards.
2. Validate the content of all received transmissions.
3. Check and report logic or data errors.
4. Monitor status for communication line malfunction or break.
5. Respond to system polling from the DMS Central Processor.
6. Check and report errors in display driver operation.
7. Check and report the failure and location of bad pixels.
8. Check and report the failure of bad fans.
9. Check and report whether the controller cabinet or DMS enclosure door is open or closed.
10. Check the operation and report the failure and location of bad power supplies.
11. Check the duration of power failures.
12. Check and report the number of occurrences the watchdog timer resets the controller.

Whenever any of the following error or failure conditions is detected, the DMS controller shall blank the DMS and shall include the error or failure in the return message:

1. The number of pixels that are not working for the particular sign type exceed a specified maximum value. The Proposer shall determine this number for each sign type and have these numbers approved by the Department.

2. The ratio of the number of pixels that achieve a commanded state divided by the number of pixels commanded to that state exceeds a legibility threshold value. The test shall include only those pixels that are contained in the character positions of the message text.
3. Communication loss greater than a configurable time value measured in minutes. The default value shall be 10 minutes. If a system poll is not received within a configurable threshold period, the controller shall blank all signs connected to it. The configuration of system polling shall also have an option for disabling this feature.
4. Upon detection of a power failure to the DMS controller or the DMS display(s) connected to the controller, the current message displayed on the DMS just prior to the power failure shall be retained in memory.
5. Upon power restoration, the DMS shall remain blank if the duration of the power failure exceeded the configurable long term power failure duration threshold, else the previous message shall be restored to its respective DMS. The default value of the long term power failure duration threshold shall be 10 minutes.
6. Overheating condition in DMS enclosure: The LED dimming circuit shall also incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the it does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs, the DMS shall blank-out until the temperature has returned to safe operating levels.
7. Information on each of the specific failures shall be sent to the DMS Central Processor.

Each DMS controller shall have the capability of displaying messages transmitted directly from a DMS Central Processor or Sign Programmer in addition to displaying locally commanded messages from a pre-programmed local message library. Each sign's local message library shall have the capacity to store a minimum of 256 display messages with related display attributes for each message, such as flashing rate and percent "on" time. The local message library shall consist of:

1. A "changeable, non-volatile" local message library stored in battery-backed RAM. The changeable local message library shall be programmable through both the DMS Central Processor and the Sign Programmer.
2. A "permanent, non-volatile" local message library, stored on EPROM shall be provided. Battery-backed RAM memory shall not be acceptable. If a microprocessor-based controller is used, then EEPROM, flash RAM or similar technology memory devices, programmed as described herein, may be used to store the message library.

Each DMS controller shall write messages on the DMS at a minimum rate of 300 characters per second.

Each DMS controller shall have an easily accessible and clearly labeled ON/OFF switch. When in the "OFF" position all power shall be disconnected from the DMS control electronics and matrix units and the DMS shall blank-out.

The Proposer shall provide a means of establishing a monetary reset switch on the DMS controller. The contact switch shall reset the DMS controller when depressed. Operation of the momentary contact switch shall not require the user to hold the switch in the depressed position for more than 0.25 seconds.

The DMS controller shall interface and communicate with one or more Operator Interfaces, as indicated on the Contract Drawings. Operator Interfaces and associated functions shall be as described elsewhere herein.

The DMS controller shall be provided with all software and hardware required to perform the following functions:

1. Password protection to restrict access to control and configuration functions.
2. Fully programmable parameters for all functions described in this section.
3. Real-time clock and calendar for timing and scheduling of automatic functions. The calendar shall automatically adjust itself for leap years, and for changeover from Standard to Daylight savings time and back.
4. Variable message flash rate and percent "on" time.
    a. Flash rate shall be adjustable in one-tenth second increments.
    b. Percent "on" time shall be adjustable from 0 to 9.9 seconds, in one-tenth second increments.
5. Multi-page messages with variable page display times that are adjustable in one-tenth second increments from 0 to 15.0 seconds.
6. Negative text inversion (or inverse/reverse video) - switch between illuminated text on a dark background or dark text on an illuminated background. Inverse/reverse video shall be implemented with the use of standard NTCIP foreground and background objects.
7. Configurable line justification (center, left or right) with center justification as the default setting.
8. Configurable page justification (top, center, bottom) with center justification as the default setting.
9. Configurable message duration parameter, to specify how long the current message should remain displayed regardless of the status of the communications with the DMS Central Processor.
10. Communications Loss message threshold, to specify how long the current message should remain displayed in the absence of communications with the DMS Central Processor.
11. Control of pixel luminance levels, both directly and based on ambient light levels obtained from the photocells. Luminance levels shall be stored in the DMS controller and shall be adjustable, in a range of 0 to 255, on either a continuous logarithmic basis, to match the normal human eye luminous response characteristic, or a 1/2 incremental dimming basis, where each lower dimming level is 1/2 the previous level.
12. Monitoring of each pixel of the DMS.
13. Monitoring of power failures: When a power failure is detected, the displayed message shall be retained in memory. If power to the DMS controller is restored within a configurable period of time, the last displayed message shall be restored. If the duration of the power failure exceeds the configured period of time, the DMS shall remain blank, until a command to display a message is received. Upon restoration of power, the DMS controller shall report the occurrence, time and duration of the power failure, to the DMS Central Processor or Sign Programmer, if connected.
14. Hardware watchdog timer: The DMS controller shall have a hardware watchdog timer that shall check for a stall condition in the controller hardware, software or firmware. While the

DMS controller is powered on, the software shall poll the watchdog timer. Upon reset, the watchdog timer shall initialize its timing circuit. If the watchdog timing circuit times out without being reset by the software, the watchdog counter shall be incremented and the watchdog shall reset the controller to clear a potential stall condition from the hardware, software or firmware and send an error message to the DMS Central Processor or Sign Programmer (if connected) to advise of the condition. The number of occurrences that the watchdog timer resets the controller shall be transmitted to the DMS Central Processor or Sign Programmer (if connected) upon request and then cleared.

15. Programmable Font Sets: The DMS controller shall support multiple programmable font sets. At a minimum, this should include fonts for 6", 9", 12", and 18" character heights, variable and fixed width fonts, and single, double, and triple stroke fonts. Each font set shall be capable of being programmed from the DMS Central Processor or the Sign Programmer if connected. Additional font sets may be provided at no additional cost and will be considered as additional value added to the proposal.
16. Each font set shall include, but not be limited to, all upper case letters, numerals, punctuation marks and arrows that are displayed in each of the eight cardinal directions.
17. Customizable and Standard Graphics Library: Provide a suite of pre-generated MUTCD style symbols, along with the ability to modify or create independent symbols, saving of new graphics and editing. The library should hold a minimum of 50 graphics.
18. The DMS controller shall keep a log of all system errors, malfunctions, automatic operations and locally controlled commands and activities. All logs shall be time and date stamped. The DMS controller shall have sufficient memory to store a minimum of 500 log entries. If 100% of the log storage memory has been reached without a successful download to the DMS Central Processor or a Sign Programmer, the oldest log entry shall be overwritten. The DMS controller shall download all log entries to a DMS Central Processor or Sign Programmer, upon user request from one of these devices and clear the log.

15.8 Controller Cabinet

All DMS controller cabinets will be furnished and installed by DelDOT's Traffic Signal/ITS Construction Contractor. Coordinate with DelDOT to confirm size, layout, power supply, and mounting/orientation of DMS controller cabinets prior to executing each individual purchase order.

15.9 Communications

Provide layout space for a cellular modem and antenna, Ethernet network switches, and/or 4.9GHz communications network equipment.

The DMS controller shall have a minimum of two (2) serial data and one (1) Ethernet communications ports to facilitate simultaneous communications for local and remote control, programming, and diagnostics.

When connected to a serial port, the DMS shall automatically use the NTCIP communications stack associated with serial communications, i.e., NTCIP 2101, NTCIP 2201, and NTCIP 2301.

When connected to the Ethernet port, the DMS shall automatically use the NTCIP communications stack associated with Ethernet communications, i.e., NTCIP 2104, NTCIP 2202, and NTCIP 2301. All ports shall be configurable such that:

1. Communications with the serial ports shall support all typical serial baud rates ranging from 1200 to 115,200 baud.
2. Communications with the Ethernet port shall be capable of communicating via TCP/IP or UDP/IP at 10 or 100 MB.

The serial ports in the DMS sign controller shall be protected with surge protection to protect the modem communication port from over-voltage and overcurrent conditions between each signal line and ground.

15.10 Software

Furnish NTCIP compatible control/diagnostic software for the purpose of troubleshooting and testing. The software shall send requests and receive responses over any TCP/IP-based network for the functions of controlling DMS messaging, monitoring system status and performing DMS diagnostics (detecting failed pixels, display drivers, power supplies, alarm conditions, etc.).

For the details and definitions for the actual NTCIP communications protocols used to accomplish this, Section 9.0.

16.0 DMS System Type 7 – Variable Speed Limit Sign (Full Matrix)

16.1 General

Design and furnish a Light Emitting Diode (LED) Dynamic Message Sign providing a full matrix color display for variable speed limit display applications. The DMS matrix shall be sized sufficient to provide a graphical display of an MUTCD-compliant speed limit sign (black letters on white background) with a pixel pitch of between 0.79 to 0.81 inches. The active graphical display area shall be a minimum of 48 inches wide by 60 inches tall and be able to display characters at a minimum height of 18". The sign shall provide front access to all interior components.

Provide a fully debugged DMS system complete with all individual units, components, software modules, cabling, connectors etc. that are completely compatible with each other and are capable of being controlled by the current ATMS being operated at the Department TMC.

16.2 Housing/Enclosure

Design and furnish a DMS enclosure of a design and shape as to house all necessary display modules, display driver electronics, transformers, power supplies and other internal sign equipment.

Provide a weatherproof housing and internal equipment rated to withstand a humidity range of 0-99% non-condensing.

Construct enclosure of a corrosion resistant aluminum material conforming to the following:

1. Sheet aluminum shall be fabricated from aluminum alloy sheet meeting the requirements of ASTM B 209, Alloy 5052, Temper H3, or equivalent, minimum 0.125 inch thick. Cast aluminum shall be fabricated from aluminum alloy meeting the requirements of ASTM B 686, Alloy A 356 (A 13560) or equivalent. Flat cast surfaces exceeding 12 inches in both directions shall have a minimum thickness of 0.25 inches. Flat cast surfaces not exceeding 12 inches in both directions shall have a minimum thickness of 0.187 inches.
2. All DMS enclosures shall meet the requirements for TYPE 3R enclosures according to NEMA Standard Publication 250. All seams and openings shall be designed to prevent entry of water resulting from high pressure washing of the DMS enclosure.
3. Unpainted aluminum DMS enclosures shall be fabricated from mill-finish material and shall be cleaned using appropriate methods that will remove oil, film, weld black, and mill ink marks and render the surface clean, bright, smooth, and non-sticky to touch. Isolate all adjacent dissimilar materials, as approved by the Department.
4. All nuts and bolts used in the DMS assembly shall be stainless steel. All connecting surfaces shall be weatherproof and watertight when secured. All internal components shall be mounted so that there are no external protrusions.
5. The DMS shall be in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except as modified herein: The DMS enclosures shall be designed and constructed to present a clean, neat appearance and the equipment located inside shall be adequately protected from moisture, dust, dirt, corrosion, and excessive heat.

6. All surfaces shall be suitably protected from the weather. All corners and seams shall be heli-arc welded to provide a weatherproof seal around the entire case.
7. The DMS enclosure shall not be adversely affected by salt from the roadways or marine environments or chemicals or fumes discharged from nearby automobiles, industries and other sources. The interior of the DMS face window and the LEDs shall be easily accessible for cleaning and other maintenance.
8. Appropriate precautions, such as heating elements or ventilation fans or openings, shall be taken to ensure that condensation does not occur between the matrix elements and the DMS window face, and that the environment inside all enclosures remains within the temperature and humidity limits required for proper operation of the sign's electronic components.
9. Provide temperature sensor(s) in the DMS enclosure that is/are controlled and monitored by the DMS controller. Provide the capability for user defined critical thresholds to be established and changed remotely from the Department TMC or other location using the sign controller.
10. Provide humidity sensor(s) within the DMS enclosure that can detect relative humidity from 0%-100% in 1% or smaller increments. Provide an interface between the humidity sensor and the DMS controller which allows humidity levels to be monitored remotely from the TMC. Provide a sensor with an accuracy that exceeds 5% relative humidity.
11. All hinges used shall be continuous stainless steel, equipped with stainless steel hinge pins. Each hinge shall be secured with stainless steel bolts and lock nuts. The hinge pins and bolts shall be tamper proof.
12. The dead load shall consist of the total weight as installed of the DMS enclosure and appurtenances. The point of application of weights of the individual items shall be their representative centers of gravity.
13. Ice load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except that ice load shall be applied to all sides and top surfaces of the DMS enclosure simultaneously.
14. Wind load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals, except as modified herein: the enclosure and their mountings shall withstand a sustained wind speed of 90 miles per hour (mph), with a gust factor of 1.3.
15. Full 100 percent impact shall be used for handling and erection stress.

The DMS shall be capable of being mounted to steel posts as well as overhead sign structures.

Removal of any of the display modules or any other electronic or electrical component, shall not alter the structural integrity of the DMS display assembly or the DMS enclosure.

Access opening shall allow maintenance personnel immediate access to circuit boards and internal sign parts, without having to remove any item in the sign, or the need to use any tools or to remove any device that could be dropped or lost, such as a locking pin or bolt. Each opening shall be sealed to prevent the elements from entering, and shall have at least two locking points to keep unauthorized persons from accessing the interior of the DMS. In addition, each opening shall be provided with rigid, telescopic, retention device, to keep the panel in the open position. All panels, when in the open position, shall not obstruct any portion of the opening. The opening system shall pull the panel tight

and compress a gasket located around the perimeter. The gasket shall prevent water from entering the interior of the cabinet.

All serviceable components shall be modular, interchangeable and removable from within the DMS enclosure. The sign design shall allow unobstructed and convenient access to all serviceable components within the DMS enclosure and between the DMS display and the DMS display cover.

Drain holes shall be provided and designed to remove any condensation that may form inside the DMS enclosure and allow any water that may have collected in the housing to escape. All holes shall be screened to prevent small objects, insects and creatures from entering into the enclosure.

Heating, cooling and/or dehumidifying equipment shall be sized to maintain the internal DMS enclosure temperature within the operating ranges of the electric, electronic and mechanical equipment components. The environmental equipment shall have controls which shall shut down the DMS just prior to the temperature that the interior of the enclosure reaches the rated maximum operating temperature of the LEDs, and shall restore operation when the temperature has returned to safe operating levels. The shutdown shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

Electric ventilation fans shall be provided to generate positive pressure ventilation and shall be sized to provide 25 percent excess ventilation capacity, with one fan inoperative, over that required to maintain the DMS enclosure interior temperature within the range over which the DMS components can operate without failure or degradation, during full daylight heat gain conditions. All fans shall have ball or roller bearings. Fan operation and failure shall be reported to the DMS Central Processor via the communications protocol.

Louvered air inlets with removable, non-proprietary 500 micron, 2-stage filters and air deflector, sized to provide a maximum air intake velocity of 600 feet per minute with all fans operating. The direction of airflow and the filter characteristics (i.e., filter model number, type, dimensions, and particle size) shall be permanently engraved on each air vent. Exhaust air vents, if without filters, shall be screened to prevent small objects and creatures from entering into the enclosure.

A vent-free DMS housing for front access devices will be considered if satisfactory evidence of proper operation is supplied with the technical submittal, including factory or third-party certification. Vent-free design shall ensure that the DMS enclosure interior temperature does not exceed the maximum range of the DMS components to ensure continued operation without failure or degradation, particularly during full daylight heat gain.

16.3 LEDs

The LEDs that make up the display modules shall be high luminous intensity T-1 3/4" type manufactured by a reputable manufacturer. The LEDs shall have an ultraviolet light inhibitor in the epoxy dome package and be of a production type already tested for use in high vibration commercial traffic environments and climate of the northeastern United States.

Each Full-color DMS LED module shall be comprised of Red Green and Blue LEDs that meet the following specifications:

1. Red LEDs shall utilize AlInGaP semiconductor technology and shall emit red light that has a peak wavelength of 615-635nm.
2. Green LEDs shall utilize InGaN semiconductor technology and shall emit green light that has a peak wavelength of 520-535nm.
3. Blue LEDs shall utilize InGaN semiconductor technology and shall emit blue light that has a peak wavelength of 464-475nm.

All LEDs shall have a nominal viewing cone of 30 degrees with a half-power angle of 15 degrees measured from the longitudinal axis of the LED.

The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

The LEDs used in the display shall be obtained from batches sorted for luminous output, where the highest luminosity LED in the batch shall not be more than fifty percent more luminous than the lowest luminosity LED in the batch when operated at the manufacturer's recommended drive current. To ensure uniformity of display and operational life, all LEDs used to make up a display module shall be obtained from the same manufacturing batch.

The LED manufacturer shall perform intensity sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive luminous intensity "bins" as defined by the LED manufacturer.

The LED manufacturer shall perform color sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive color "bins" as defined by the LED manufacturer.

The LED mean time before failure (MTBF) shall be a minimum of 100,000 hours of elapsed time calendar hours use in an ambient temperature of 131 degrees Fahrenheit, based on an average daily on-time usage factor of 50%, when driven at the specific forward current recommended by the LED manufacturer for normal daylight DMS display operation. As part of the LED manufacturer's technical specification sheet submittal, the specific forward current shall be noted.

The statistical average long term light output degradation of the LEDs used in the display, operated at the LED manufacturer's recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure in an ambient temperature of 131 degrees Fahrenheit, shall not exceed the following:

1. A maximum of 10% reduction in light output after 10,000 hours of continuous on time.
2. A maximum of 25% reduction in light output after 50,000 hours of continuous on time.
3. A maximum of 30% reduction in light output after 100,000 hours of continuous on-time.
4. Manufacturer's documentation for high temperature operating life (HTOL) shall indicate if HTOL values are based upon actual or extrapolated data.

16.4 Display Modules

The LED display modules shall have a minimum refresh rate of 60 times per second to prevent visible flicker.

The LEDs shall be grouped in pixels consisting of discrete LEDs arranged in a continuous matrix display with individual pixel addressability. The centers of all pixels shall be arranged so as to maintain the same horizontal and vertical spacing between adjacent pixels. All pixels shall be replaceable. The LED grouping and mounting angle shall be optimized for maximum readability.

The electronics for the DMS shall be fully configured to drive the total required number of LEDs. The failure of any one pixel shall not affect the operation of any other pixel. The power driver circuitry shall be designed to minimize power consumption. Each LED display module shall have a diagnostic capability to detect a failure on the LED display module, down to the pixel level and report the failure to the DMS controller.

Removal of any display module shall not affect the operation of the remaining modules.

The LED modules shall be protected from degradation due to sunlight. The method used shall not obstruct the view of the display or reduce the viewing angle below that provided by an unprotected LED module. The method and design of the DMS sunlight protection shall be approved by the Department.

Each pixel shall contain an adequate number of discrete LEDs, based on a nominal pixel spacing of 0.79 to 0.81 inches, center to center, to meet the luminosity requirements herein.

Each discrete LED on the display module is driven at the LED manufacturer’s recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure.

All DMS must be capable of meeting or exceeding the Manual of Uniform Traffic Control Devices (MUTCD) guidelines for inter-character and inter-line spacing of 25% and 50% of character height, respectively.

The 18” character of the Freeway DMS shall be clearly visible and legible from in-vehicle distance of 1,000 feet from the DMS face under clear daylight and nighttime conditions with the DMS face positioned in the roadway line of sight.

16.5 Dimming Circuitry

The DMS shall have a photocell controlled dimming circuit which shall automatically adjust the luminance of the LED display pixels in accordance with ambient light conditions. As part of the Proposer's submittal, a complete schematic of the LED display power, driver and dimming circuits shall be provided for approval by the Department.

Continuous current drive shall be used at the maximum brightness level. The current used for maximum brightness shall not exceed the current used to achieve the rated mean time before failure (MTBF). The current used for maximum brightness shall be indicated as part of the submittal.

For luminance levels less than maximum brightness, either continuous current drive or current pulse width modulation shall be used to dim the LEDs. If pulse width modulation is used, the dimming circuit shall be designed so that the maximum, instantaneous and average currents shall not exceed the rated peak and transient forward current ratings of the LEDs.

The DMS shall be equipped with a minimum of two external light sensors oriented in opposite directions and shall be scaled for up to 100,000 lux.

The LED dimming circuit shall also incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the LED current does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs the DMS shall blank-out, until the temperature has returned to safe operating levels.

The LED dimming circuit shall not cause the LED display to flicker as the temperature oscillates above and below the rated operating temperature of the LEDs.

16.6 Power Supply

The DMS shall be operated at a low internal DC voltage not exceeding 24 Volts.

The quantity of power supplies and current rating of each power supply shall be at least 25% spare capacity over that required to light every pixel of the DMS at full brightness.

The DMS and controller shall have redundant power supplies wired so that in the event of a failure of any one power supply, the second power supply shall automatically power that portion of the sign. Power supply failure shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

The power supplies shall be short circuit protected and shall reset automatically after 5 seconds of AC power off. The power supplies shall be protected by a suitable overcurrent protection device.

The power supply shall have an efficiency rating of 85%, minimum.

The operating temperature range of the power supply inside the DMS enclosure shall be negative 20 degrees Fahrenheit to 140 degrees Fahrenheit.

The power supply shall be UL listed.

16.7 Controller

The DMS controller shall be a microprocessor-based unit with sufficient on-board memory and input and output interfaces to provide all the functions required by this Section.

The DMS controller shall accommodate both local and remote control from multiple host devices as described herein. Local control shall be supported from a locally connected sign programmer. Remote control shall be supported from a remotely located DMS Central Processor (control computer system).

The DMS controller shall receive and interpret commands sent by the host device to either configure the DMS or cause a requested message to be displayed on the DMS. Based on the command, the DMS Controller shall provide return data to the host device to provide information about the status of the sign.

The DMS controller shall be capable of simultaneously receiving commands from and transmitting status data to multiple host devices; i.e., the sign programmer, local control panel and the DMS Central Processor.

The method of control of the DMS shall be dependent upon the setting of the Control Mode Selector switch in each local control panel. This switch shall allow for two modes of operation:

"Remote" mode: This is the normal mode of operation of the DMS, where all control is from a remote DMS Central Processor, via NTCIP data exchanged directly between the remote DMS Central Processor and the DMS controller.

"Local" mode: When the Control Mode Selector switch is in this position, control from the remote DMS Central Processor shall be disabled and the DMS shall be controlled in accordance with commands entered via the message selector switch on the Local Control Panel or a NTCIP data exchanged directly with a locally connected Sign Programmer. When in "local" mode, the remote DMS Central Processor shall still be able to monitor the status of the DMS.

When switching from one mode to another, the DMS shall continue to display its current message, until it receives a command to display another message, from either the remote DMS Central Processor or the local controls, as applicable.

A change of position of the mode selector switch shall be immediately reported to the DMS Central Processor in the form of an alarm, and shall be logged internally at the site CPU for retrieval on the next polling cycle, and in accordance with the communications protocol.

Each DMS controller shall have error detection and reporting features which shall be utilized to guard against incomplete or incorrect information transmission, message generation and display on the DMS, as well as provide capability to detect a failure down to a replaceable component and report the failure and failed component. All errors and hardware failures shall be logged and reported to the DMS Central Processor or Sign Programmer (if connected) via the communications protocol. The DMS controller shall have the capability to automatically recover from failure conditions when the failure conditions are corrected or the failures are no longer present, and report the restored operation of the DMS to the DMS Central Processor or Sign Programmer (if connected).

The DMS controller shall have diagnostic capabilities features to:

1. Perform redundant checking of all data received and transmitted, and incorporate cyclic redundancy check (CRC) error detection logic, as specified by the NTCIP standards.
2. Validate the content of all received transmissions.
3. Check and report logic or data errors.
4. Monitor status for communication line malfunction or break.
5. Respond to system polling from the DMS Central Processor.
6. Check and report errors in display driver operation.
7. Check and report the failure and location of bad pixels.
8. Check and report the failure of bad fans.
9. Check and report whether the controller cabinet or DMS enclosure door is open or closed.
10. Check the operation and report the failure and location of bad power supplies.

11. Check the duration of power failures.
12. Check and report the number of occurrences the watchdog timer resets the controller.

Whenever any of the following error or failure conditions is detected, the DMS controller shall blank the DMS and shall include the error or failure in the return message:

1. The number of pixels that are not working for the particular sign type exceed a specified maximum value. The Proposer shall determine this number for each sign type and have these numbers approved by the Department.
2. The ratio of the number of pixels that achieve a commanded state divided by the number of pixels commanded to that state exceeds a legibility threshold value. The test shall include only those pixels that are contained in the character positions of the message text.
3. Communication loss greater than a configurable time value measured in minutes. The default value shall be 10 minutes. If a system poll is not received within a configurable threshold period, the controller shall blank all signs connected to it. The configuration of system polling shall also have an option for disabling this feature.
4. Upon detection of a power failure to the DMS controller or the DMS display(s) connected to the controller, the current message displayed on the DMS just prior to the power failure shall be retained in memory.
5. Upon power restoration, the DMS shall remain blank if the duration of the power failure exceeded the configurable long term power failure duration threshold, else the previous message shall be restored to its respective DMS. The default value of the long term power failure duration threshold shall be 10 minutes.
6. Overheating condition in DMS enclosure: The LED dimming circuit shall also incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the it does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs, the DMS shall blank-out until the temperature has returned to safe operating levels.
7. Information on each of the specific failures shall be sent to the DMS Central Processor.

Each DMS controller shall have the capability of displaying messages transmitted directly from a DMS Central Processor or Sign Programmer in addition to displaying locally commanded messages from a pre-programmed local message library. Each sign's local message library shall have the capacity to store a minimum of 24 display messages with related display attributes for each message, such as flashing rate and percent "on" time. The local message library shall consist of:

1. A "changeable, non-volatile" local message library stored in battery-backed RAM. The changeable local message library shall be programmable through both the DMS Central Processor and the Sign Programmer.
2. A "permanent, non-volatile" local message library, stored on EPROM shall be provided. Battery-backed RAM memory shall not be acceptable. If a microprocessor-based controller is used, then EEPROM, flash RAM or similar technology memory devices, programmed as described herein, may be used to store the message library.

Each DMS controller shall have an easily accessible and clearly labeled ON/OFF switch. When in the "OFF" position all power shall be disconnected from the DMS control electronics and matrix units and the DMS shall blank-out.

The Proposer shall provide a means of establishing a monetary reset switch on the DMS controller. The contact switch shall reset the DMS controller when depressed. Operation of the momentary contact switch shall not require the user to hold the switch in the depressed position for more than 0.25 seconds.

The DMS controller shall interface and communicate with one or more Operator Interfaces, as indicated on the Contract Drawings. Operator Interfaces and associated functions shall be as described elsewhere herein.

The DMS controller shall be provided with all software and hardware required to perform the following functions:

1. Password protection to restrict access to control and configuration functions.
2. Fully programmable parameters for all functions described in this section.
3. Real-time clock and calendar for timing and scheduling of automatic functions. The calendar shall automatically adjust itself for leap years, and for changeover from Standard to Daylight savings time and back.
4. Variable message flash rate and percent "on" time.
    a. Flash rate shall be adjustable in one-tenth second increments.
    b. Percent "on" time shall be adjustable from 0 to 9.9 seconds, in one-tenth second increments.
5. Negative text inversion (or inverse/reverse video) - switch between illuminated text on a dark background or dark text on an illuminated background. Inverse/reverse video shall be implemented with the use of standard NTCIP foreground and background objects.
6. Configurable line justification (center, left or right) with center justification as the default setting.
7. Configurable page justification (top, center, bottom) with center justification as the default setting.
8. Configurable message duration parameter, to specify how long the current message should remain displayed regardless of the status of the communications with the DMS Central Processor.
9. Communications Loss message threshold, to specify how long the current message should remain displayed in the absence of communications with the DMS Central Processor.
10. Control of pixel luminance levels, both directly and based on ambient light levels obtained from the photocells. Luminance levels shall be stored in the DMS controller and shall be adjustable, in a range of 0 to 255, on either a continuous logarithmic basis, to match the normal human eye luminous response characteristic, or a 1/2 incremental dimming basis, where each lower dimming level is 1/2 the previous level.
11. Monitoring of each pixel of the DMS.
12. Monitoring of power failures: When a power failure is detected, the displayed message shall be retained in memory. If power to the DMS controller is restored within a configurable period

of time, the last displayed message shall be restored. If the duration of the power failure exceeds the configured period of time, the DMS shall remain blank, until a command to display a message is received. Upon restoration of power, the DMS controller shall report the occurrence, time and duration of the power failure, to the DMS Central Processor or Sign Programmer, if connected.

13. Hardware watchdog timer: The DMS controller shall have a hardware watchdog timer that shall check for a stall condition in the controller hardware, software or firmware. While the DMS controller is powered on, the software shall poll the watchdog timer. Upon reset, the watchdog timer shall initialize its timing circuit. If the watchdog timing circuit times out without being reset by the software, the watchdog counter shall be incremented and the watchdog shall reset the controller to clear a potential stall condition from the hardware, software or firmware and send an error message to the DMS Central Processor or Sign Programmer (if connected) to advise of the condition. The number of occurrences that the watchdog timer resets the controller shall be transmitted to the DMS Central Processor or Sign Programmer (if connected) upon request and then cleared.
14. Programmable Font Sets: The DMS controller shall support multiple programmable font sets. At a minimum, this should include MUTCD compliant fonts for regulatory signs in freeway an arterial applications.
15. Each font set shall include, but not be limited to, all upper case letters, numerals, punctuation marks and arrows that are displayed in each of the eight cardinal directions.
16. Customizable and Standard Graphics Library: Provide a suite of pre-generated MUTCD style symbols, along with the ability to modify or create independent symbols, saving of new graphics and color editing. The library should hold a minimum of 10 graphics.
17. The DMS controller shall keep a log of all system errors, malfunctions, automatic operations and locally controlled commands and activities. All logs shall be time and date stamped. The DMS controller shall have sufficient memory to store a minimum of 500 log entries. If 100% of the log storage memory has been reached without a successful download to the DMS Central Processor or a Sign Programmer, the oldest log entry shall be overwritten. The DMS controller shall download all log entries to a DMS Central Processor or Sign Programmer, upon user request from one of these devices and clear the log.
18. The DMS and Controller shall be capable of displaying a minimum of 256 different colors. DMS Controller shall be capable of displaying colors that conform to MUTCD requirements.

16.8 Controller Cabinet

All DMS controller cabinets will be furnished and installed by DelDOT's Traffic Signal/ITS Construction Contractor. Coordinate with DelDOT to confirm size, layout, power supply, and mounting/orientation of DMS controller cabinets prior to executing each individual purchase order.

16.9 Communications

Provide layout space for a cellular modem and antenna, Ethernet network switches, and/or 4.9GHz communications network equipment.

The DMS controller shall have a minimum of two (2) serial data and one (1) Ethernet communications ports to facilitate simultaneous communications for local and remote control, programming, and diagnostics.

When connected to a serial port, the DMS shall automatically use the NTCIP communications stack associated with serial communications, i.e., NTCIP 2101, NTCIP 2201, and NTCIP 2301.

When connected to the Ethernet port, the DMS shall automatically use the NTCIP communications stack associated with Ethernet communications, i.e., NTCIP 2104, NTCIP 2202, and NTCIP 2301. All ports shall be configurable such that:

3. Communications with the serial ports shall support all typical serial baud rates ranging from 1200 to 115,200 baud.
4. Communications with the Ethernet port shall be capable of communicating via TCP/IP or UDP/IP at 10 or 100 MB.

The serial ports in the DMS sign controller shall be protected with surge protection to protect the modem communication port from over-voltage and overcurrent conditions between each signal line and ground.

16.10 Software

Furnish NTCIP compatible control/diagnostic software for the purpose of troubleshooting and testing. The software shall send requests and receive responses over any TCP/IP-based network for the functions of controlling DMS messaging, monitoring system status and performing DMS diagnostics (detecting failed pixels, display drivers, power supplies, alarm conditions, etc.).

For the details and definitions for the actual NTCIP communications protocols used to accomplish this, Section 9.0.

17.0 DMS System Type 8 – Lane Use Control Sign (Full Matrix)

17.1 General

Design and furnish a Light Emitting Diode (LED) Dynamic Message Sign providing a full matrix color display for overhead lane use control applications. The DMS matrix shall be sized sufficient to provide a graphical display with a pixel pitch of between 0.79 to 0.81 inches. The active graphical display area shall be a minimum of 36 inches wide by 36 inches tall. The sign shall provide front access to all interior components.

Provide a fully debugged DMS system complete with all individual units, components, software modules, cabling, connectors etc. that are completely compatible with each other and are capable of being controlled by the current ATMS being operated at the Department TMC.

17.2 Housing/Enclosure

Design and furnish a DMS enclosure of a design and shape as to house all necessary display modules, display driver electronics, transformers, power supplies and other internal sign equipment.

Provide a weatherproof housing and internal equipment rated to withstand a humidity range of 0-99% non-condensing.

Construct enclosure of a corrosion resistant aluminum material conforming to the following:

1. Sheet aluminum shall be fabricated from aluminum alloy sheet meeting the requirements of ASTM B 209, Alloy 5052, Temper H3, or equivalent, minimum 0.125 inch thick. Cast aluminum shall be fabricated from aluminum alloy meeting the requirements of ASTM B 686, Alloy A 356 (A 13560) or equivalent. Flat cast surfaces exceeding 12 inches in both directions shall have a minimum thickness of 0.25 inches. Flat cast surfaces not exceeding 12 inches in both directions shall have a minimum thickness of 0.187 inches.
2. All DMS enclosures shall meet the requirements for TYPE 3R enclosures according to NEMA Standard Publication 250. All seams and openings shall be designed to prevent entry of water resulting from high pressure washing of the DMS enclosure.
3. Unpainted aluminum DMS enclosures shall be fabricated from mill-finish material and shall be cleaned using appropriate methods that will remove oil, film, weld black, and mill ink marks and render the surface clean, bright, smooth, and non-sticky to touch. Isolate all adjacent dissimilar materials, as approved by the Department.
4. All nuts and bolts used in the DMS assembly shall be stainless steel. All connecting surfaces shall be weatherproof and watertight when secured. All internal components shall be mounted so that there are no external protrusions.
5. The DMS shall be in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except as modified herein: The DMS enclosures shall be designed and constructed to present a clean, neat appearance and the equipment located inside shall be adequately protected from moisture, dust, dirt, corrosion, and excessive heat.

6. All surfaces shall be suitably protected from the weather. All corners and seams shall be heli-arc welded to provide a weatherproof seal around the entire case.
7. The DMS enclosure shall not be adversely affected by salt from the roadways or marine environments or chemicals or fumes discharged from nearby automobiles, industries and other sources. The interior of the DMS face window and the LEDs shall be easily accessible for cleaning and other maintenance.
8. Appropriate precautions, such as heating elements or ventilation fans or openings, shall be taken to ensure that condensation does not occur between the matrix elements and the DMS window face, and that the environment inside all enclosures remains within the temperature and humidity limits required for proper operation of the sign's electronic components.
9. Provide temperature sensor(s) in the DMS enclosure that is/are controlled and monitored by the DMS controller. Provide the capability for user defined critical thresholds to be established and changed remotely from the Department TMC or other location using the sign controller.
10. Provide humidity sensor(s) within the DMS enclosure that can detect relative humidity from 0%-100% in 1% or smaller increments. Provide an interface between the humidity sensor and the DMS controller which allows humidity levels to be monitored remotely from the TMC. Provide a sensor with an accuracy that exceeds 5% relative humidity.
11. All hinges used shall be continuous stainless steel, equipped with stainless steel hinge pins. Each hinge shall be secured with stainless steel bolts and locknuts. The hinge pins and bolts shall be tamper-proof.
12. The dead load shall consist of the total weight as installed of the DMS enclosure and appurtenances. The point of application of weights of the individual items shall be their representative centers of gravity.
13. Ice load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, except that ice load shall be applied to all sides and top surfaces of the DMS enclosure simultaneously.
14. Wind load shall be as per AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals, except as modified herein: the enclosure and their mountings shall withstand a sustained wind speed of 90 miles per hour (mph), with a gust factor of 1.3.
15. Full 100 percent impact shall be used for handling and erection stress.

The DMS shall be capable of being mounted to overhead sign structures.

Removal of any of the display modules or any other electronic or electrical component, shall not alter the structural integrity of the DMS display assembly or the DMS enclosure.

Access opening shall allow maintenance personnel immediate access to circuit boards and internal sign parts, without having to remove any item in the sign, or the need to use any tools or to remove any device that could be dropped or lost, such as a locking pin or bolt. Each opening shall be sealed to prevent the elements from entering, and shall have at least two locking points to keep unauthorized persons from accessing the interior of the DMS. In addition, each opening shall be provided with rigid, telescopic, retention device, to keep the panel in the open position. All panels, when in the open position, shall not obstruct any portion of the opening. The opening system shall pull the panel tight

and compress a gasket located around the perimeter. The gasket shall prevent water from entering the interior of the cabinet.

All serviceable components shall be modular, interchangeable and removable from within the DMS enclosure. The sign design shall allow unobstructed and convenient access to all serviceable components within the DMS enclosure and between the DMS display and the DMS display cover.

Drain holes shall be provided and designed to remove any condensation that may form inside the DMS enclosure and allow any water that may have collected in the housing to escape. All holes shall be screened to prevent small objects, insects, and creatures from entering into the enclosure.

Heating, cooling and/or dehumidifying equipment shall be sized to maintain the internal DMS enclosure temperature within the operating ranges of the electric, electronic and mechanical equipment components. The environmental equipment shall have controls which shall shut down the DMS just prior to the temperature that the interior of the enclosure reaches the rated maximum operating temperature of the LEDs, and shall restore operation when the temperature has returned to safe operating levels. The shutdown shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

Electric ventilation fans shall be provided to generate positive pressure ventilation and shall be sized to provide 25 percent excess ventilation capacity, with one fan inoperative, over that required to maintain the DMS enclosure interior temperature within the range over which the DMS components can operate without failure or degradation, during full daylight heat gain conditions. All fans shall have ball or roller bearings. Fan operation and failure shall be reported to the DMS Central Processor via the communications protocol.

Louvered air inlets with removable, non-proprietary 500 micron, 2-stage filters and air deflector, sized to provide a maximum air intake velocity of 600 feet per minute with all fans operating. The direction of airflow and the filter characteristics (i.e., filter model number, type, dimensions, and particle size) shall be permanently engraved on each air vent. Exhaust air vents, if without filters, shall be screened to prevent small objects and creatures from entering into the enclosure.

A vent-free DMS housing for front access devices will be considered if satisfactory evidence of proper operation is supplied with the technical submittal, including factory or third-party certification. Vent-free design shall ensure that the DMS enclosure interior temperature does not exceed the maximum range of the DMS components to ensure continued operation without failure or degradation, particularly during full daylight heat gain.

17.3 LEDs

The LEDs that make up the display modules shall be high luminous intensity T-1 3/4" type manufactured by a reputable manufacturer. The LEDs shall have an ultraviolet light inhibitor in the epoxy dome package and be of a production type already tested for use in high vibration commercial traffic environments and climate of the northeastern United States.

Each Full-color DMS LED module shall be comprised of Red Green and Blue LEDs that meet the following specifications:

1. Red LEDs shall utilize AlInGaP semiconductor technology and shall emit red light that has a peak wavelength of 615-635nm.
2. Green LEDs shall utilize InGaN semiconductor technology and shall emit green light that has a peak wavelength of 520-535nm.
3. Blue LEDs shall utilize InGaN semiconductor technology and shall emit blue light that has a peak wavelength of 464-475nm.

All LEDs shall have a nominal viewing cone of 30 degrees with a half-power angle of 15 degrees measured from the longitudinal axis of the LED.

The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

The LEDs used in the display shall be obtained from batches sorted for luminous output, where the highest luminosity LED in the batch shall not be more than fifty percent more luminous than the lowest luminosity LED in the batch when operated at the manufacturer's recommended drive current. To ensure uniformity of display and operational life, all LEDs used to make up a display module shall be obtained from the same manufacturing batch.

The LED manufacturer shall perform intensity sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive luminous intensity "bins" as defined by the LED manufacturer.

The LED manufacturer shall perform color sorting of the bins. LEDs shall be obtained from no more than two (2) consecutive color "bins" as defined by the LED manufacturer.

The LED mean time before failure (MTBF) shall be a minimum of 100,000 hours of elapsed time calendar hours use in an ambient temperature of 131 degrees Fahrenheit, based on an average daily on-time usage factor of 50%, when driven at the specific forward current recommended by the LED manufacturer for normal daylight DMS display operation. As part of the LED manufacturer's technical specification sheet submittal, the specific forward current shall be noted.

The statistical average long term light output degradation of the LEDs used in the display, operated at the LED manufacturer's recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure in an ambient temperature of 131 degrees Fahrenheit, shall not exceed the following:

5. A maximum of 10% reduction in light output after 10,000 hours of continuous on time.
1. A maximum of 25% reduction in light output after 50,000 hours of continuous on time.
2. A maximum of 30% reduction in light output after 100,000 hours of continuous on-time.
3. Manufacturer's documentation for high temperature operating life (HTOL) shall indicate if HTOL values are based upon actual or extrapolated data.

17.4 Display Modules

The LED display modules shall have a minimum refresh rate of 60 times per second to prevent visible flicker.

The LEDs shall be grouped in pixels consisting of discrete LEDs arranged in a continuous matrix display with individual pixel addressability. The centers of all pixels shall be arranged so as to maintain the same horizontal and vertical spacing between adjacent pixels. All pixels shall be replaceable. The LED grouping and mounting angle shall be optimized for maximum readability.

The electronics for the DMS shall be fully configured to drive the total required number of LEDs. The failure of any one pixel shall not affect the operation of any other pixel. The power driver circuitry shall be designed to minimize power consumption. Each LED display module shall have a diagnostic capability to detect a failure on the LED display module, down to the pixel level and report the failure to the DMS controller.

Removal of any display module shall not affect the operation of the remaining modules.

The LED modules shall be protected from degradation due to sunlight. The method used shall not obstruct the view of the display or reduce the viewing angle below that provided by an unprotected LED module. The method and design of the DMS sunlight protection shall be approved by the Department.

Each pixel shall contain an adequate number of discrete LEDs, based on a nominal pixel spacing of 0.79 to 0.81 inches, center to center, to meet the luminosity requirements herein.

Each discrete LED on the display module is driven at the LED manufacturer’s recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure.

All DMS must be capable of meeting or exceeding the Manual of Uniform Traffic Control Devices (MUTCD) guidelines for inter-character and inter-line spacing of 25% and 50% of character height, respectively.

The 18” character of the Freeway DMS shall be clearly visible and legible from in-vehicle distance of 1,000 feet from the DMS face under clear daylight and nighttime conditions with the DMS face positioned in the roadway line of sight.

17.5 Dimming Circuitry

The DMS shall have a photocell controlled dimming circuit which shall automatically adjust the luminance of the LED display pixels in accordance with ambient light conditions. As part of the Proposer's submittal, a complete schematic of the LED display power, driver and dimming circuits shall be provided for approval by the Department.

Continuous current drive shall be used at the maximum brightness level. The current used for maximum brightness shall not exceed the current used to achieve the rated mean time before failure (MTBF). The current used for maximum brightness shall be indicated as part of the submittal.

For luminance levels less than maximum brightness, either continuous current drive or current pulse width modulation shall be used to dim the LEDs. If pulse width modulation is used, the dimming circuit shall be designed so that the maximum, instantaneous and average currents shall not exceed the rated peak and transient forward current ratings of the LEDs.

The DMS shall be equipped with a minimum of two external light sensors oriented in opposite directions and shall be scaled for up to 100,000 lux.

The LED dimming circuit shall also incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the LED current does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs the DMS shall blank-out, until the temperature has returned to safe operating levels.

The LED dimming circuit shall not cause the LED display to flicker as the temperature oscillates above and below the rated operating temperature of the LEDs.

17.6 Power Supply

The DMS shall be operated at a low internal DC voltage not exceeding 24 Volts.

The quantity of power supplies and current rating of each power supply shall be at least 25% spare capacity over that required to light every pixel of the DMS at full brightness.

The DMS and controller shall have redundant power supplies wired so that in the event of a failure of any one power supply, the second power supply shall automatically power that portion of the sign. Power supply failure shall be automatically reported by the DMS controller when polled by the DMS Central Processor.

The power supplies shall be short circuit protected and shall reset automatically after 5 seconds of AC power off. The power supplies shall be protected by a suitable overcurrent protection device.

The power supply shall have an efficiency rating of 85%, minimum.

The operating temperature range of the power supply inside the DMS enclosure shall be negative 20 degrees Fahrenheit to 140 degrees Fahrenheit.

The power supply shall be UL listed.

17.7 Controller

The DMS controller shall be a microprocessor-based unit with sufficient on-board memory and input and output interfaces to provide all the functions required by this Section.

The DMS controller shall be capable of controlling a minimum of six (6) DMS utilized for lane use control simultaneously.

The DMS controller shall accommodate both local and remote control from multiple host devices as described herein. Local control shall be supported from a locally connected sign programmer. Remote control shall be supported from a remotely located DMS Central Processor (control computer system).

The DMS controller shall receive and interpret commands sent by the host device to either configure the DMS or cause a requested message to be displayed on the DMS. Based on the command, the DMS

Controller shall provide return data to the host device to provide information about the status of the sign.

The DMS controller shall be capable of simultaneously receiving commands from and transmitting status data to multiple host devices; i.e., the sign programmer, local control panel and the DMS Central Processor.

The method of control of the DMS shall be dependent upon the setting of the Control Mode Selector switch in each local control panel. This switch shall allow for two modes of operation:

"Remote" mode: This is the normal mode of operation of the DMS, where all control is from a remote DMS Central Processor, via NTCIP data exchanged directly between the remote DMS Central Processor and the DMS controller.

"Local" mode: When the Control Mode Selector switch is in this position, control from the remote DMS Central Processor shall be disabled and the DMS shall be controlled in accordance with commands entered via the message selector switch on the Local Control Panel or a NTCIP data exchanged directly with a locally connected Sign Programmer. When in "local" mode, the remote DMS Central Processor shall still be able to monitor the status of the DMS.

When switching from one mode to another, the DMS shall continue to display its current message, until it receives a command to display another message, from either the remote DMS Central Processor or the local controls, as applicable.

A change of position of the mode selector switch shall be immediately reported to the DMS Central Processor in the form of an alarm, and shall be logged internally at the site CPU for retrieval on the next polling cycle, and in accordance with the communications protocol.

Each DMS controller shall have error detection and reporting features which shall be utilized to guard against incomplete or incorrect information transmission, message generation and display on the DMS, as well as provide capability to detect a failure down to a replaceable component and report the failure and failed component. All errors and hardware failures shall be logged and reported to the DMS Central Processor or Sign Programmer (if connected) via the communications protocol. The DMS controller shall have the capability to automatically recover from failure conditions when the failure conditions are corrected or the failures are no longer present, and report the restored operation of the DMS to the DMS Central Processor or Sign Programmer (if connected).

The DMS controller shall have diagnostic capabilities features to:

1. Perform redundant checking of all data received and transmitted, and incorporate cyclic redundancy check (CRC) error detection logic, as specified by the NTCIP standards.
2. Validate the content of all received transmissions.
3. Check and report logic or data errors.
4. Monitor status for communication line malfunction or break.
5. Respond to system polling from the DMS Central Processor.
6. Check and report errors in display driver operation.
7. Check and report the failure and location of bad pixels.

8. Check and report the failure of bad fans.
9. Check and report whether the controller cabinet or DMS enclosure door is open or closed.
10. Check the operation and report the failure and location of bad power supplies.
11. Check the duration of power failures.
12. Check and report the number of occurrences the watchdog timer resets the controller.

Whenever any of the following error or failure conditions is detected, the DMS controller shall blank the DMS and shall include the error or failure in the return message:

1. The number of pixels that are not working for the particular sign type exceed a specified maximum value. The Proposer shall determine this number for each sign type and have these numbers approved by the Department.
2. The ratio of the number of pixels that achieve a commanded state divided by the number of pixels commanded to that state exceeds a legibility threshold value. The test shall include only those pixels that are contained in the character positions of the message text.
3. Communication loss greater than a configurable time value measured in minutes. The default value shall be 10 minutes. If a system poll is not received within a configurable threshold period, the controller shall blank all signs connected to it. The configuration of system polling shall also have an option for disabling this feature.
4. Upon detection of a power failure to the DMS controller or the DMS display(s) connected to the controller, the current message displayed on the DMS just prior to the power failure shall be retained in memory.
5. Upon power restoration, the DMS shall remain blank if the duration of the power failure exceeded the configurable long term power failure duration threshold, else the previous message shall be restored to its respective DMS. The default value of the long term power failure duration threshold shall be 10 minutes.
6. Overheating condition in DMS enclosure: The LED dimming circuit shall also incorporate temperature controlled dimming, which shall reduce the current through the LEDs based on the temperature inside the DMS enclosure, so that the it does not exceed the rated LED current at that temperature. If the temperature of the DMS exceeds the rated operating temperature of the LEDs, the DMS shall blank-out until the temperature has returned to safe operating levels.
7. Information on each of the specific failures shall be sent to the DMS Central Processor.

Each DMS controller shall have the capability of displaying messages transmitted directly from a DMS Central Processor or Sign Programmer in addition to displaying locally commanded messages from a pre-programmed local message library. Each sign's local message library shall have the capacity to store a minimum of 24 display messages with related display attributes for each message, such as flashing rate and percent "on" time. The local message library shall consist of:

1. A "changeable, non-volatile" local message library stored in battery-backed RAM. The changeable local message library shall be programmable through both the DMS Central Processor and the Sign Programmer.
2. A "permanent, non-volatile" local message library, stored on EPROM shall be provided. Battery-backed RAM memory shall not be acceptable. If a microprocessor-based controller is

used, then EEPROM, flash RAM or similar technology memory devices, programmed as described herein, may be used to store the message library.

Each DMS controller shall have an easily accessible and clearly labeled ON/OFF switch. When in the "OFF" position all power shall be disconnected from the DMS control electronics and matrix units and the DMS shall blank-out.

The Proposer shall provide a means of establishing a monetary reset switch on the DMS controller. The contact switch shall reset the DMS controller when depressed. Operation of the momentary contact switch shall not require the user to hold the switch in the depressed position for more than 0.25 seconds.

The DMS controller shall interface and communicate with one or more Operator Interfaces, as indicated on the Contract Drawings. Operator Interfaces and associated functions shall be as described elsewhere herein.

The DMS controller shall be provided with all software and hardware required to perform the following functions:

1. Password protection to restrict access to control and configuration functions.
2. Fully programmable parameters for all functions described in this section.
3. Real-time clock and calendar for timing and scheduling of automatic functions. The calendar shall automatically adjust itself for leap years, and for changeover from Standard to Daylight savings time and back.
4. Variable message flash rate and percent "on" time.
    a. Flash rate shall be adjustable in one-tenth second increments.
    b. Percent "on" time shall be adjustable from 0 to 9.9 seconds, in one-tenth second increments.
5. Negative text inversion (or inverse/reverse video) - switch between illuminated text on a dark background or dark text on an illuminated background. Inverse/reverse video shall be implemented with the use of standard NTCIP foreground and background objects.
6. Configurable line justification (center, left or right) with center justification as the default setting.
7. Configurable page justification (top, center, bottom) with center justification as the default setting.
8. Configurable message duration parameter, to specify how long the current message should remain displayed regardless of the status of the communications with the DMS Central Processor.
9. Communications Loss message threshold, to specify how long the current message should remain displayed in the absence of communications with the DMS Central Processor.
10. Control of pixel luminance levels, both directly and based on ambient light levels obtained from the photocells. Luminance levels shall be stored in the DMS controller and shall be adjustable, in a range of 0 to 255, on either a continuous logarithmic basis, to match the normal human eye luminous response characteristic, or a 1/2 incremental dimming basis, where each lower dimming level is 1/2 the previous level.
11. Monitoring of each pixel of the DMS.

12. Monitoring of power failures: When a power failure is detected, the displayed message shall be retained in memory. If power to the DMS controller is restored within a configurable period of time, the last displayed message shall be restored. If the duration of the power failure exceeds the configured period of time, the DMS shall remain blank, until a command to display a message is received. Upon restoration of power, the DMS controller shall report the occurrence, time and duration of the power failure, to the DMS Central Processor or Sign Programmer, if connected.
13. Hardware watchdog timer: The DMS controller shall have a hardware watchdog timer that shall check for a stall condition in the controller hardware, software or firmware. While the DMS controller is powered on, the software shall poll the watchdog timer. Upon reset, the watchdog timer shall initialize its timing circuit. If the watchdog timing circuit times out without being reset by the software, the watchdog counter shall be incremented and the watchdog shall reset the controller to clear a potential stall condition from the hardware, software or firmware and send an error message to the DMS Central Processor or Sign Programmer (if connected) to advise of the condition. The number of occurrences that the watchdog timer resets the controller shall be transmitted to the DMS Central Processor or Sign Programmer (if connected) upon request and then cleared.
14. Programmable Font Sets: The DMS controller shall support multiple programmable font sets. At a minimum, this should include MUTCD compliant fonts for regulatory signs in freeway an arterial applications.
15. Each font set shall include, but not be limited to, all upper case letters, numerals, punctuation marks and arrows that are displayed in each of the eight cardinal directions.
16. Customizable and Standard Graphics Library: Provide a suite of pre-generated MUTCD style symbols, along with the ability to modify or create independent symbols, saving of new graphics and color editing. The library should hold a minimum of 10 graphics.
17. The DMS controller shall keep a log of all system errors, malfunctions, automatic operations and locally controlled commands and activities. All logs shall be time and date stamped. The DMS controller shall have sufficient memory to store a minimum of 500 log entries. If 100% of the log storage memory has been reached without a successful download to the DMS Central Processor or a Sign Programmer, the oldest log entry shall be overwritten. The DMS controller shall download all log entries to a DMS Central Processor or Sign Programmer, upon user request from one of these devices and clear the log.
18. The DMS and Controller shall be capable of displaying a minimum of 256 different colors. DMS Controller shall be capable of displaying colors that conform to MUTCD requirements.

17.8 Controller Cabinet

All DMS controller cabinets will be furnished and installed by DelDOT's Traffic Signal/ITS Construction Contractor. Coordinate with DelDOT to confirm size, layout, power supply, and mounting/orientation of DMS controller cabinets prior to executing each individual purchase order.

17.9 Communications

Provide layout space for a cellular modem and antenna, Ethernet network switches, and/or 4.9GHz communications network equipment.

The DMS controller shall have a minimum of two (2) serial data and one (1) Ethernet communications ports to facilitate simultaneous communications for local and remote control, programming, and diagnostics.

When connected to a serial port, the DMS shall automatically use the NTCIP communications stack associated with serial communications, i.e., NTCIP 2101, NTCIP 2201, and NTCIP 2301.

When connected to the Ethernet port, the DMS shall automatically use the NTCIP communications stack associated with Ethernet communications, i.e., NTCIP 2104, NTCIP 2202, and NTCIP 2301. All ports shall be configurable such that:

1. Communications with the serial ports shall support all typical serial baud rates ranging from 1200 to 115,200 baud.
2. Communications with the Ethernet port shall be capable of communicating via TCP/IP or UDP/IP at 10 or 100 MB.

The serial ports in the DMS sign controller shall be protected with surge protection to protect the modem communication port from over-voltage and overcurrent conditions between each signal line and ground.

17.10 Software

Furnish NTCIP compatible control/diagnostic software for the purpose of troubleshooting and testing. The software shall send requests and receive responses over any TCP/IP-based network for the functions of controlling DMS messaging, monitoring system status and performing DMS diagnostics (detecting failed pixels, display drivers, power supplies, alarm conditions, etc.).

For the details and definitions for the actual NTCIP communications protocols used to accomplish this, Section 9.0.